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Sixty Years of Progress in Pump Design

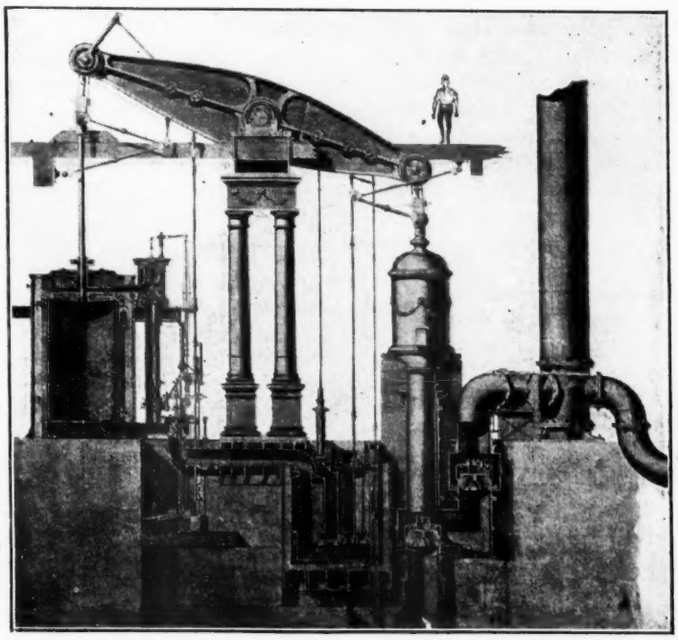
The crude, unwieldy machine on the right is a Cornish pumping engine, which was one of two installed in Cleveland's first water-supply station in 1855; the compact, efficient-looking units below are a part of the city's present pumping system.

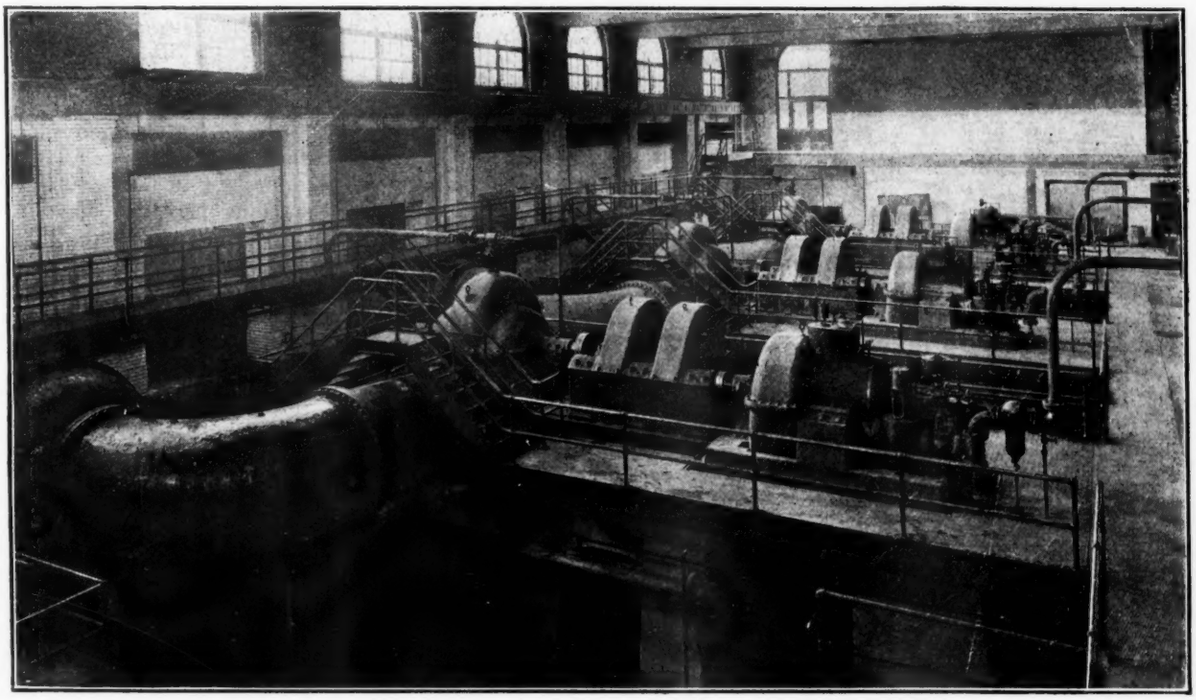
The old engine had a steam cylinder of 70 in. inside diameter with a stroke of 10 ft., had a maximum speed of 10 r.p.m. and delivered about 4,000 gal. per day; the new turbine-pump has a capacity of 100,000,000 gal. per day—25,000 times as much.

The Division Station of Cleveland, of which the units shown below are a part, was the subject of a paper read by J. N. H. Christman before the June meeting of the American Water Works Association. The purpose of the paper was to give an example of modern pumping practice. Its author admitted, however, that "all the conditions in the station are not ideal. If the station were rebuilt now, some changes would certainly be made." Yet it was only completed in 1917!

Thus the world moves on, and what is new today becomes obsolete tomorrow. Who knows but that *Power* will come out in 1981 with the very picture shown below, labeled, "A group of funny old pumps used by our forefathers in 1920"? Or are we, perhaps, approaching the point where improvement can go but little further?

History says "No." Certainly the designers of the old Cornish engine would have sworn that but little improvement could be expected over their latest creation. "Modern Practice" always seems, but never is, the ultimate. Each year—each month, even—brings changes in what had been considered ideal methods of doing things.





Kern River Three Development Has Highest Head Francis Turbines Installed

ON MAY 5 of this year, Kern River Three plant of the Southern California Edison Co. was officially put into operation. This plant (see Fig. 1) is a reinforced-concrete structure 88 x 130 ft. located six miles north of Kernville village and 48 miles by automobile road from Caliento, a station on the main line of the Southern Pacific Railroad. A concrete dam (Fig. 2) built on the bedrock of the river bed forms a low diverting wall with rounded crest.

Two head gates, 8-ft. square, motor-operated, open into a concrete flume built along the river bank for about one-half mile, supported on a trestle of concrete bents and emptying into a sand box, or settling basin, of unique design (Figs. 3 and 4). The sand box is made necessary by the excessive amount of sand and silt carried in all streams draining the Sierras. It is built with two compartments so that either may be emptied, if necessary, without interrupting the flow to the plant. Generous sluicing arrangements, however, have been made, so that only under exceptional circumstances will it become necessary to use the two-compartment feature. Looking down on this structure from the side of the canyon (Fig. 3) one is given the impression of a huge ship with its streamline bow and stern, cast high and dry on the rocks without having suffered any damage from the experience.

TWO vertical-shaft 22,500-hp. Francis-type turbines are installed each operating under an effective head of 800 ft. Two runners are provided for each unit, one for 50-cycle and the other for 60-cycle operation. Special arrangements are provided to control the load on the machines when one is operating at a frequency of 60 and the other at 50. Water is carried through a series of tunnels aggregating 60,000 ft. in length, the longest single bore being 7,132 ft. Two penstocks are 2,520 ft. long, made of steel plates ranging in thickness from 3/8 to 1 1/16 in. Power is generated at 11,000 volts and goes directly to transformers and is stepped up to 75,000 volts for transmission. This plant will generate about 200,000,000 kw.-hr. per year and will result in conserving 900,000 bbl. of oil annually. Ten million dollars is the approximate cost of the development and is a part of the company's $200,000,000 construction program, which contemplates bringing into service a minimum of 750,000 hp. from the waters of Big Creek, San Joaquin and Kern Rivers. At least 50,000-hp. development per year is necessary to meet the demands on the company for power.

Just below the sand box the water enters the first of a series of tunnels aggregating nearly 60,000 ft., the longest single bore being 7,132 ft. Each tunnel is connected to the next by a concrete flume built either on a bench along the side of the canyon or supported on concrete bents where it was found necessary to cross gulches.

Water from the forebay is carried to the power house in two steel penstocks, each 2,520 ft. in length. The pipes are 84 in. in diameter at the top and taper to 60 in. at the entrance to the power house, with thicknesses of metal varying from $\frac{3}{8}$ in. to $1\frac{1}{16}$ in. Economical design called for riveted pipe for a length of 795 ft. and lap-welded for the remainder. Anchors designed to take care of thrust caused by hydrostatic head and friction are located on supporting piers at angle points with expansion joints midway between. To measure the flow of water, a venturi meter was installed at the bottom of each line with recording instruments in the power house.

In this plant the main prime movers are two vertical-shaft Francis-type turbines. These are direct-connected to generators and have a rated capacity of 22,500 hp., under an 800-ft. effective net head, the highest head ever attempted with this type of wheel. Operating conditions make it necessary to deliver power part of the time at 50 cycles and part of the time at 60 cycles, and to meet this condition two runners are furnished with each machine, one for operation at 500 r.p.m. and one for 600 r.p.m. Means are provided for easily and quickly changing runners. The guaranteed efficiency of each turbine at either 500 or 600 r.p.m. is 86 per cent at full load and 90 per cent at three-quarter load.

The center line of the runner inlet is 16 ft. above low tail water, and the upper part of the draft tube is cast iron. Immediately below the turbine casing the draft-tube section is made removable, so that the runner can be easily changed. Below the cast-iron section the draft tube is in the form of a flaring elbow formed in concrete and discharging horizontally into the tailrace below low-water level. Turbine casings are of the cast-steel volute type, with an inlet diameter of 48 in., made in two parts, the joints being in a vertical plane at right angles to the direction of inlet flow. The speed ring is a separate steel casting in one piece bolted to the casing. Each turbine has 16 movable guide vanes, which are of forged steel with spindles forged integral with the vanes connecting through stuffing boxes and rocker arms to an outside operating ring. At two opposite points two servo-motor cylinders 25 in. in diameter are connected to the ring, operated under the control of the governor by oil at 200 lb. pressure. The turbine shaft is oil-tempered nickel steel 15 in. in diameter, with a flanged coupling connected to the generator shaft. Any unbalanced weight of the rotating parts is carried on a water-cooled spring-type thrust bearing at the top of the generator.

Hydraulic lift to balance the rotating parts is obtained by the use of close-fitting seal rings fitted to the runner and casing, which forms unequal annular areas above and below the runner. These areas are connected by a balance pipe to equalize the pressure, the lower space being enough larger than the space on top of the runner to give the required uplift. A relief pipe leads from the space above the central part of the runner to the draft tube to relieve any pressure that may be communicated past the upper seal ring. At the entrance to the turbine casing, between the turbine and the penstock valve, is a cast-steel "Y"

branch leading to a relief valve. The stem of this valve is mechanically connected to the operating ring of the turbine gates so that when the turbine gates close, the relief valve opens and vice versa, thus relieving the penstock from surges due to sudden changes in velocity. This relief valve can also be connected through a dashpot so that it will close slowly after a sudden gate closure, thus acting as a water-saving device.

The governor is of the compensated floating lever type, mounted on the power-house floor adjacent to the generator. It actuates a relay valve which controls the servo-motor cylinders and has a restoring mechanism to prevent hunting and to give practically dead-beat regulation. It will respond to speed fluctuations varying one-half of one per cent from normal and may be adjusted to obtain a difference of speed between full load and no load and from zero to approximately 5 per cent. The servo-motor stroke under control of the governor is normally two and one-half to three seconds from full load on or off and can be adjusted to vary the time of either the closing or opening stroke. The governor head is driven through a belt from the turbine shaft and is provided with a clutch that may be thrown out when it is desired to control the speed by hand. Remote control of the governor is provided for synchronizing from the switchboard through a direct current reversible motor mounted on a bracket attached to the actuator and geared to the speed-control mechanism. Speed-limit stops are provided to prevent a predetermined speed being exceeded while synchronizing. In case of an accident to the revolving element of the governor, a device is incorporated which will tend to close the turbine gates. There is also an adjustable load-limiting device so set as to automatically limit the amount of load carried by the turbine. Independent of the oil-pressure system there is a hand-operated pump mounted on the basement floor with sufficient capacity to move the servo-motor the full amount of its stroke.

FIG. 1. POWER PLANT, SHOWING LAYING OF PENSTOCKS

Hydraulic conditions on Kern River are such that at certain times of the year there is not sufficient water to operate both units at full load, and an interconnected device has been arranged by the turbine builders so that when one turbine is operating on a fluctuating 60-cycle load, the other unit will use all the water not required for the first unit to generate as much power as possible at 50 cycles. This device consists essentially of a mechanical connection between the governors of the two units so that a change in load on the 60-cycle or master machine will cause an inverse movement of the turbine gates of the other machine and also a device operated from a float in the forebay to compensate for the fluctuating water level due to the changes in gate opening of the machines.

A balanced-plunger penstock valve (Fig. 5) is located immediately above the branch leading to the relief valve. It is cast-steel throughout, 60-in. diameter at the inlet and 52-in. at the outlet. The movement of the balanced plunger is controlled by automatic valves, which in turn are controlled by a remote hydraulic control from the switchboard, pressure for which is obtained from the penstock above the penstock valve. Above this valve also there is a second "Y" branch leading to a bursting plug of novel construction. This bursting plug consists of a cast-steel nozzle surrounded by an annular space, the discharge from the nozzle and annular space being covered by a single plate held to the body of the plug by means of bolts which are turned down in the body to such a diameter that they will break when the total pressure against the cover plate exceeds a predetermined amount. Under normal operation the pressure on the cover plate is that due to the normal penstock pressure over the area of the bursting plug nozzle only. When the pressure rises a predetermined amount above normal, it operates a small relief valve which communicates from the nozzle to the annular space surrounding it and allows this increased pressure to enter the annular space. This doubles the area exposed to pressure on the cover plates, and the total pressure will be considerably in excess of the ultimate strength of the connecting bolts. The principal advantage claimed for this type of bursting plug is that it is more positive in its action, any pressure rise above normal being greatly intensified in its action on the breaking element, thus causing the plug to give way very quickly.

Near the end of the draft tube there are provided slots for structural-steel gates which may be lowered to shut off the passage between the tailrace and the water outside so that the tailrace and draft tube can be pumped out by pumps provided for that purpose. This will be necessary at times, not only for inspecting the draft tube, but also in the event that the turbine runners have to be changed at high water, in which case, if there were no tailrace gates, the removable upper

section of the draft tube would be below high-water level. The pumps for circulating cooling water to the transformers and for supplying water for general station and domestic use are located in a separate room just

FIG. 2. IMPOUNDING DAM ON KERN RIVER ABOVE THE FOURTEEN-MILE TUNNEL AND FLUME SYSTEM WHICH CARRIES ITS WATERS TO PLANT NUMBER THREE

outside the main generator building. There are two pumps for transformer circulation and two for water supply, taking their water from the river. For supplying ventilating air for the electric generators, two humidifiers are installed in the basement under the main generator room and air from the outside is led through these humidifiers and up through the generator air gaps by fans on the generator rotor. Each humidifier has a capacity of 60,000 cu.ft. of air per minute.

FIG. 3. SAND BOX ABOVE THE ENTRANCE TO THE SERIES OF TUNNELS

Lubricating oil for the generator and turbine bearings is supplied from head tanks located at a considerable elevation above the generator so as to give ample oil pressure, and after passing through the bearings, is returned to a sump tank from which it is pumped to a receiving tank, whence it flows by gravity through a three-compartment oil filter arranged so that any one compartment can be cut out for cleaning while the remaining two carry the total capacity of the system, which is 35 gal. per min. From the filter the oil is again pumped to the head tanks by means of rotary screw motor-driven oil pumps installed in duplicate. Oil in excess of the amount required is bypassed from the head tanks back to the sump tank. Each sump tank has a capacity sufficient for about thirty minutes' supply of oil to both units. There is, at the switchboard, a float gage which registers the height of oil in the sump tanks and gives an alarm in case the oil level is dangerously low.

The generator equipment consists of two 11,000-volt, three-phase 50- or 60-cycle generating units, each having a maximum capacity of 17,500 kva. The generators are of the revolving-field type and are guaranteed when operated at 90 per cent power factor to have an efficiency of 96.8 per cent at full load.

Each generator has two guide bearings and a thrust bearing which supports the entire revolving weight of the generator and turbine. This thrust bearing is of a spring-supported disc type and is designed to carry a total revolving weight of approximately 50,000 lb. Directly connected to each generator is a compound-wound exciter rated at 95 kw., 250 volts. There is also a spare motor-driven exciter which is capable of exciting the fields of both generators. The main generators are star-connected and underground. The neutrals are brought outside of the frame and current transformers inserted ahead of the star connection. The secondaries of these current transformers are tied to the secondaries of the current transformers in the main leads with a differential connection, thence through instantaneous relays to protect the generator from internal trouble. The main leads from the generator go directly to the terminals of the step-up transformers, there being no disconnecting or oil switches between generator and transformers. Thus the generator and transformers are considered a unit and the minimum amount of low-tension equipment is installed. Each generator's transformer bank is made up of three single-phase 5,833-kva., 75,000-volt star to 11,000-volt delta water-cooled transformers. A spare transformer is so located between the two banks that it can be

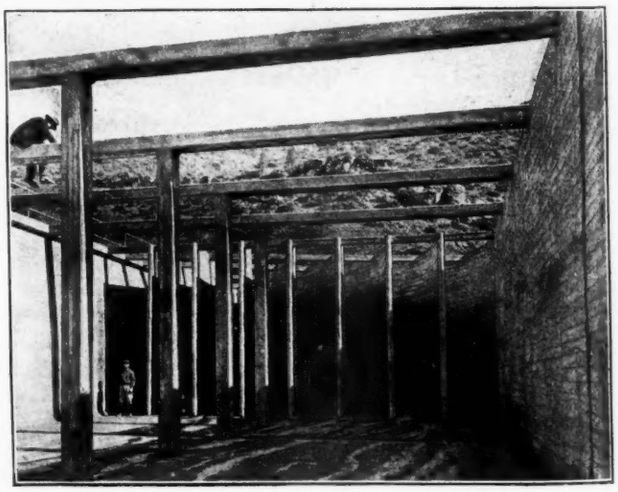


FIG. 4. INTERIOR OF SAND BOX WHICH REMOVES THE SILT AND SAND FROM THE WATER

connected in place of any one transformer in case of a burn-out without moving either the spare or the damaged transformer. The 75,000-volt side of the transformers is connected to either of two high-tension buses through oil-switches, and the two 75,000-volt outgoing

lines are connected to either of the buses in a similar manner. These buses are equipped with disconnecting switches located in the middle of the station, so that when it is required to operate one generator at 50 cycles and the other at 60 cycles, the station may be cut in two and operated as two entirely separate plants and still have the advantage and flexibility of a double bus on each. The lines leave the building through porcelain bushings in the roof, then to a steel structure on which the lines are dead-ended. Here are located aluminum-cell lightning arresters, one set on each line. The transmission line from this station is approximately 45 miles in length and connects to the 150,000-volt Big Creek lines through what is called the Vestal Substation.

Station auxiliaries are all motor-driven and supplied from a double 2,400-volt bus. These buses are in reality a continuation of the 75,000-volt buses; that is, on the end of each high bus is an oil switch connected to a three-phase 400-kva. 75,000-volt to 2,400-volt step-down transformer. This, at first thought, may seem an unnecessary transformation, but it makes it possible to have the 11,000-volt generator leads entirely free from connections and switching equipment, which are in many cases a source of trouble. Any switching equipment connected so close to the generator is necessarily very large and must be capable of handling enormous amounts of power in case of short-circuits, even though it may be connected to a service that carries a very small load. The unit scheme also prevents lightning or any trouble on local camp lines being felt on the low side of the main transformer.

All gates and valves at forebay, which is about one-half mile distant from the power house, are electrically operated and are controlled from the main switchboard. The number of wires between the control board and

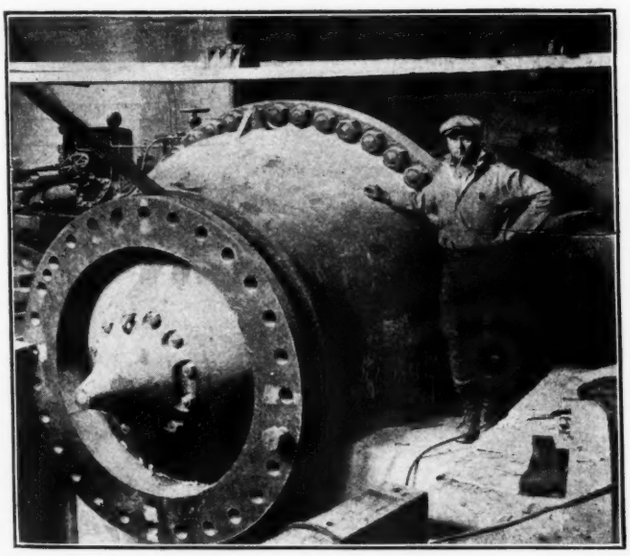


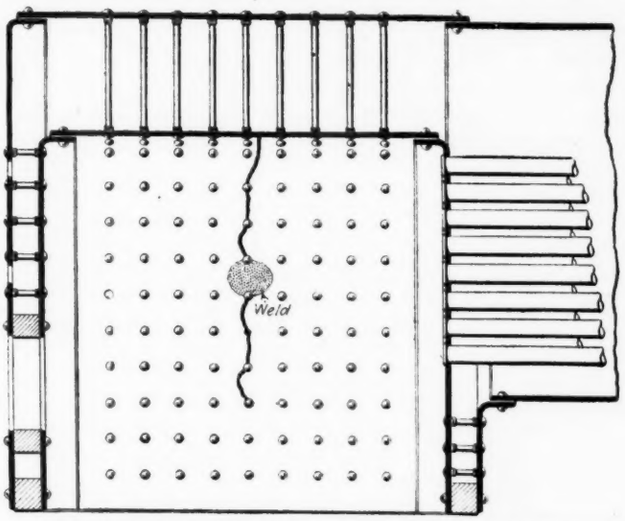
FIG. 5. HYDRAULICALLY OPERATED PENSTOCK VALVE

forebay is reduced to a minimum by means of a motor-driven selector switch located at the forebay. On this selector switch there are contacts for each motor-operated gate. The motor operating the switch is controlled from the power house and turns the switch to a position indicated by lamps, which connects gate-control switches to the desired gate. Thus the set of control wires and switches may be connected to the gate which it is desired to operate, and the control switches will then control the gate. The number of wires saved by this scheme considerably more than paid for the building of the device.

The development was designed and built by the Engineering Department of the Southern California Edison Co. under the general direction of W. A. Brackenridge, senior vice-president.

Boiler Ruptures With Man in Firebox

Stories are often told of outlandish tricks played by tornadoes in some unfortunate district of the country, but here is a real freak story—the case of a boiler that



A SECTION THROUGH PART OF THE BOILER, SHOWING THE POSITION OF THE BREAK

"went up" while an inspector was going peacefully about his work in the firebox, and with no pressure up.

The boiler was of the stationary locomotive type and had been out of service a long time. At the time of the "explosion" the inspector was inside the firebox searching for defects, and he certainly found one. He was naturally rather startled to hear a report like the discharge of a cannon and at first thought that a stick of dynamite had exploded. He found, however, that a furnace sheet had ripped open for a length of about 36 in. directly through a weld that had been made in the sheet. The rupture extended about equal distances on either side of the "built-up" part that had been welded. The sketch shows the location of the break.

The explanation of this peculiar occurrence is thought to be that the sheet had been overheated in the welding process, crystallized, and was therefore under a severe shrinkage strain. The defective part was practically free of scale. The handhole plates at the bottom of the boiler were off, but the manhole plate had been replaced.

According to the inspector the condition represented by this boiler, so strikingly demonstrated in this case, may have resulted in some disastrous explosions that have occurred, the causes of which have never been determined. The incident is certainly a forceful demonstration of the dangerous stresses that may result from improper heating in the welding process.

This is an authentic report of an occurrence at the plant of the Calco Co., Bound Brook, N. J., where the two boilers were examined by an inspector of the Fidelity and Casualty Co. at the request of the Standard Bitulithic Co., who contemplated their purchase.

Testing and Improving Ventilation

Control of Humidity and Circulation More Important Than Disposal of Carbonic Dioxide

By CHARLES L. HUBBARD

A SHORT time ago the writer had the interesting experience of passing through all the various atmospheric changes commonly encountered in an office during the entire year, in the short space of thirty minutes.

These different conditions were brought about by simply varying the temperature and humidity of a small room by means of a device similar in principle to a standard air washer, in which the air was recirculated through a coarse spray of water resembling rain. The room was of the usual size for a single office, containing perhaps 1,800 cu.ft. of space, and had been occupied during the forenoon by two people without change of air other than that due to natural leakage around the door and windows. At the beginning of the test the temperature of the room was 78 deg. and the relative humidity 15 per cent, about the usual conditions found in the average office building during the winter, and such as to give a sense of overheating and a feeling of dryness and irritation in the throat and nasal passages. After the machine had been running for a few minutes, the humidity began to rise and the temperature to fall, the latter being due to the withdrawal of heat from the air by the evaporation of the water. At the end of ten or fifteen minutes a temperature of 70 deg. and a humidity of 40 per cent had been obtained, conditions ideal for bodily comfort when accompanied by a moderate air movement. The atmosphere now had the quality of a June day at a fairly high altitude, giving one a decided feeling of buoyancy and capacity for work, both mental and physical. The water in the humidifier was now heated, and the room temperature and humidity began to rise. At 80 deg. and 70 per cent humidity, conditions became like those of an August day, oppressive and giving one a feeling of languor. When a temperature of 90 deg. was reached, with a humidity of 85 per cent, one was perspiring freely, there was a sensation of weight upon the chest and a general sense of discomfort difficult to locate.

Maintaining Comfortable Conditions

Of course everyone is familiar with the physical effect of atmospheric conditions, but experiencing the entire range in so short a time could but impress one with the importance of maintaining the most comfortable conditions possible in an office or industrial building, from a purely material standpoint.

Sensations like those caused by the combination of a high temperature and relative humidity supplemented by disagreeable odors, are experienced in crowded rooms like theaters and halls lacking effective means of ventilation. For years the ill effects of breathing air of this kind were supposed to be due to the presence of an excess of carbon dioxide and other poisonous substances given off from the lungs in the act of breathing, and to the exhaustion of oxygen from the air. The remedy for this was thought to be a matter of dilution, accomplished by bringing in large volumes of outside air, and for many years ventilating systems have been designed on this basis. Outside country air contains, on an average, about 4 parts of carbon dioxide in 10,000, and it was supposed this should never be allowed to rise above 10 at the most, and efforts were made to limit it to 6 or 7 parts in 10,000 in buildings like schools, churches, theaters, etc.

Recent investigations seem to show, however, that the human lungs will stand a concentration of carbon dioxide up to about 500 parts in 10,000 of air and always contain approximately 400 parts. In the act of breathing only enough air is taken into the lungs to maintain this concentration. Any increase acts on certain nerves which quicken respiration and so increase the supply of oxygen as to neutralize a portion of the carbon dioxide and bring the concentration back to normal. This action is entirely automatic and takes care of any change in the proportions of oxygen and carbon dioxide in the surrounding air without assistance. Dilution of the air, other than that which takes place by leakage through the building construction, is not usually necessary, so far as the *chemical* composition of the air is concerned. There are, however, certain *physical* conditions of the air which are best remedied by dilution, such as the presence of dust, odors, moisture, etc., so that in many cases it is advisable to supply a certain amount of fresh air mechanically, as noted later.

Varying Conditions Without Supplying or Removing Air

The sensations of discomfort in the poorly ventilated theater or schoolroom are produced in exactly the same way as in the office previously mentioned, where any degree of comfort and atmospheric "purity" could be obtained by varying the temperature and humidity without either supplying or removing air. An adult at rest generates from 300 to 400 thermal units per hour, or enough to raise the temperature of 1,000 cu.ft. of air from 15 to 20 deg. In addition to this, moisture is given off, both in the air exhaled from the lungs and by perspiration from the surface of the body, so that a crowded room, without ventilation, soon becomes overheated and the air laden with moisture, giving the effect of oppression and discomfort already described. The actual sensations experienced are due to a slight rise in the bodily temperature, or in other words, a condition of mild fever is produced.

Under normal conditions, with a room temperature of 68 to 70 deg., a relative humidity of 40 to 50 per cent and a free movement of air over the body, this heat and moisture will be carried away as fast as it is given off, in which case no rise in bodily temperature is produced and we have the sensation of comfort which accompanies "good ventilation." With an excess of moisture in the air, evaporation is retarded and its cooling effect reduced; without circulation an envelope

of warm moist air surrounds the body and reduces cooling both by conduction and evaporation.

Modern methods of ventilation are therefore based upon a proper temperature and humidity control, air movement, and under certain conditions the removal of dust, odors and bacteria, depending on the type of

PSYCHROMETRIC TABLE COVERING ORDINARY ROOM TEMPERATURE

Dry-Bulb, Temp., Deg.	Wet-Bulb, Temp., Deg.	Relative Humidity, per Cent	Pounds Moisture per 1,000 Cu.Ft.	Dry-Bulb, Temp., Deg.	Wet-Bulb, Temp., Deg.	Relative Humidity, per Cent	Pounds Moisture, per 1,000 Cu.Ft.
64	60	80	0.757	70	60	55	0.643
	59	75	0.710		59	52	0.597
	58	70	0.662		58	48	0.551
	57	65	0.615		57	45	0.517
	56	61	0.577		56	41	0.471
	55	57	0.539		55	37	0.425
	54	52	0.492		54	34	0.390
	53	48	0.454		53	30	0.344
	52	44	0.416		52	26	0.298
66	60	71	0.716	72	60	50	0.612
	59	66	0.666		59	46	0.553
	58	62	0.625		58	43	0.525
	57	58	0.585		57	39	0.477
	56	53	0.535		56	35	0.428
	55	49	0.494		55	32	0.392
	54	45	0.454		54	29	0.355
	53	41	0.414		53	25	0.305
	52	37	0.373		52	21	0.257
68	60	63	0.679	74	60	44	0.574
	59	59	0.635		59	40	0.522
	58	55	0.592		58	37	0.482
	57	51	0.549		57	34	0.443
	56	47	0.506		56	31	0.404
	55	43	0.463		55	27	0.352
	54	39	0.420		54	24	0.313
	53	35	0.377		53	20	0.261
	52	31	0.334		52	16	0.218

room or building under consideration and the processes carried on within it.

Having shown, in a general way, the conditions to be overcome or improved in order to secure a healthful and comfortable atmosphere, the next step is to see how this may be brought about in the simplest and most practical manner and how present ventilating equipment may be utilized to the best advantage.

Testing the Atmospheric Conditions

Before any attempt is made to improve the atmospheric conditions in a room or building, the approximate state of affairs, at least, should be determined

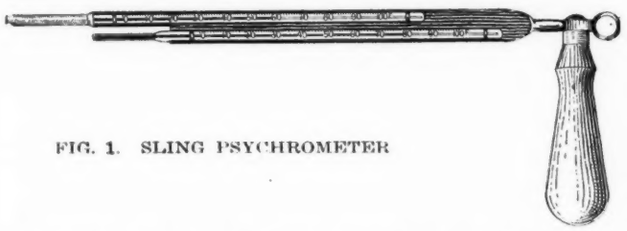


FIG. 1. SLING PSYCHROMETER

by simple tests. The most important of these, temperature and humidity, may be measured by a sling psychrometer, a common form of which is shown in Fig. 1. This consists of wet-bulb and dry-bulb thermometers attached to a pivot handle, used by moistening the wicking covering the wet bulb and whirling the instrument rapidly in the air until there is no further drop in the wet-bulb temperature. The dry bulb indicates the temperature of the room and the wet bulb the relative humidity for the given dry-bulb temperature.

These readings are to be used in connection with a "psychrometric" chart or table, a portion of the latter, covering ordinary room temperatures, being given herewith.

Suppose, for example, the psychrometer gives a dry-bulb temperature of 74 deg. and a wet-bulb of 60 deg. From the table we find the air contains 0.574 lb. of moisture per 1,000 cu.ft., which gives a relative humidity of 44 per cent at the aforementioned dry-bulb temperature. In like manner we find a dry-bulb of 70 deg.

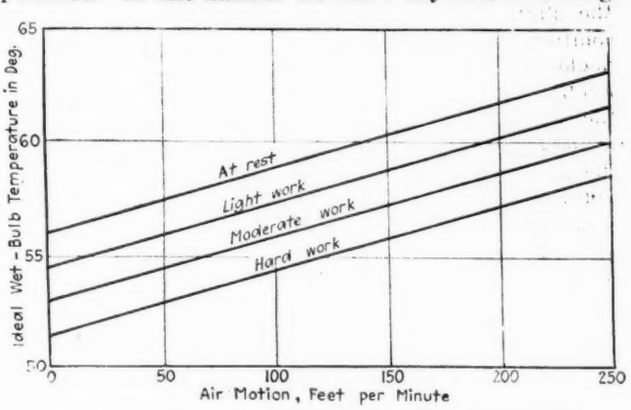


FIG. 2. CHART FOR WET-BULB TEMPERATURE CORRECTIONS

and a wet-bulb of 56 deg. gives a relative humidity of 41 per cent, which has been found to be the most comfortable combination of temperature and humidity for ordinary conditions in still air and has led to the adoption of 56 deg. as the *ideal* wet-bulb temperature, with suitable corrections for variations in air movement and degree of physical exertion.

These corrections, for the usual range, may be read from the curves in Fig. 2. The psychrometer, in connection with Table I, gives the room temperature, wet-bulb temperature, relative humidity, and moisture content, while the curves in Fig. 2 furnish the proper variation from the ideal wet-bulb temperature for actual conditions.

The Kata-Thermometer

A new device, known as the "Kata-thermometer," has recently been brought out, which gives not only the temperature and humidity, but also the movement of the air, thus indicating all three of the most essential conditions for atmospheric comfort. This instrument has wet- and dry-bulb thermometers of large size, graduated in the usual manner, but with special marks at 95 and 100 deg. Tests are made by heating both thermometers to a temperature somewhat above 100 deg. in warm water, quickly wiping the dry-bulb, and placing in a rack, as shown in Fig. 3. Stop-watch readings are then tak n of the time required for each thermometer to fall from 100 to 95 deg., and by allowing the temperatures of each to come to rest, we have the room temperature, the wet-b u l b temperature, and the time required for each to cool over a range covering that of the bodily changes under extreme conditions. Standards for comparison are made by noting the time required for cooling under various healthful atmospheric conditions which it is desired to imitate. Recent tests show the dry-bulb reading of this instrument to

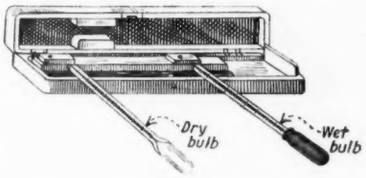


FIG. 3. KATA-THERMOMETER

be of great value in determining the comfortableness of indoor conditions where air currents from fans form an important factor.

As designed at present, the wet-bulb Kata-thermometer seems to have little practical value owing to the shortness of its range, which makes the recording of the slight variations produced on either side of the comfort zone exceedingly difficult. A series of tests made on six different days, with ordinary thermometer readings varying from 69 to 79 deg., showed that when the time required for the dry-bulb of the Kata-thermometer to fall from 100 to 95 deg. was 170 seconds, the air seemed uncomfortably warm, but when the time fell to 120 seconds, owing to increased air movements, it seemed too cool. Hence, for the greatest degree of comfort under ordinary conditions, it would seem that the time of change for the dry-bulb should lie between these extremes. Another interesting point in connection with this test was the fact that with the fan in operation a temperature of 87 deg. was found as comfortable as 72 deg. without it.

Determining Direction and Velocity of Air Movement

Direction and velocity of air movement are approximately determined in various ways according to local conditions. For low velocities, smoke or Chinese punk may be used, a small amount of gunpowder flashed in a pan, or vapor from an ammonium chloride apparatus being employed for the former. Although smoke is excellent for indicating the direction and approximate velocity of air currents, small toy balloons are more easily timed for accurate work. For higher velocities of 200 ft. per minute and above, an anemometer is more convenient in many cases.

Tests for dust are best made by holding a piece of glass coated with fresh varnish close in front of a cylinder through which the air is passing at a known velocity. By counting the dust particles that adhere to the glass per unit area, under a microscope, and knowing the air velocity and time of exposure, the number of particles per cubic foot of air may be approximated. Glass slides ruled especially for dust counts may be obtained for this purpose.

Tests for bacteria are commonly made where the room is exposed to outside or street dust, also in hospitals and institutions. Dust produced in mechanical processes does not commonly contain bacteria, and tests of this kind are usually outside the work of the engineer, although comparatively simple, the method generally employed being to expose in the room a 4-in. plate containing a preparation of agar for two minutes. This is kept at a uniform temperature of 22 deg. C. for 48 hours, and the number of colonies or "spots" that appear on the plate are then counted.

Odors are tested simply by the sense of smell, by one coming into the room from the outer air. Accurate tests for air distribution are made by determining the proportion of carbon dioxide in different parts of the room and comparing them, but for ordinary work a smoke test will give a pretty fair idea of the air movement and distribution.

After the tests are made, the next step is to make practical use of the information thus gained. Just how far this can be carried out will depend upon local conditions and the season of the year. During the "heating season" room temperature and humidity may be pretty carefully controlled by the use of suitable equipment and due care in operation. In general, much more discomfort is experienced from overheating than from the reverse condition, and furthermore, the occupants of an overheated room may suffer from chilliness if there is not sufficient moisture in the air.

Automatic control of room temperature is about the only satisfactory method in offices, schoolrooms, etc., and in fact, any room of small or medium size where changes in temperature take place rapidly. The large rooms of shops and factories are more easily controlled by hand regulation than smaller ones, but even here automatic control is always to be recommended if the expense is not prohibitive. In considering a system of this kind, the saving in fuel should be taken into account and also the increased efficiency of the working force, due to better atmospheric conditions.

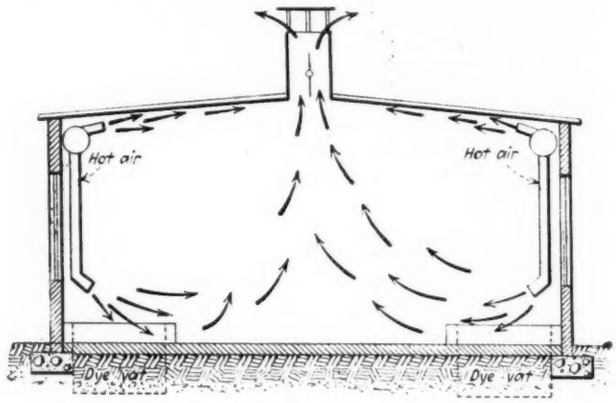


FIG. 4. VENTILATION DIAGRAM FOR DYEHOUSE, ETC.

In case it seems advisable to use hand regulation, the responsibility should be turned over to a single person in each room, or one person may be given charge of several rooms, making frequent visits to each. If regular workmen employed for other purposes are put in charge of this, special arrangements as to compensation should be made. Valves and piping should be so arranged that heat may be turned on and off by the manipulation of a limited number of the former. If forced hot-water is employed, a schedule of proper temperatures should be carefully worked out for differing outside weather conditions.

When the outside temperature reaches a point where heat is not required, then the matter passes out of control to a considerable extent and resort must be had to open windows, electric fans for stirring the air, and cooling by washers supplied with cold well water or refrigerating coils, according to local conditions.

Relation of Inside to Outside Temperature

In the practice of artificial cooling it is found that the inside temperature should bear a certain relation to that outside, and that this difference ordinarily should not exceed about 10 deg., else a chill will be experienced when coming into a room thus treated. The general method of determining the volume of air and drop in temperature for maintaining a given difference between the inside and outside is practically the same as in heating, except that the processes are reversed, and a temperature difference of 10 deg. instead of 70 or 80 is assumed in computing the heat loss or cooling effect necessary.

While an appreciable difference may be obtained by the use of an air washer when recirculating the spray water, the cooling is due to evaporation, and although it is possible to reduce the air temperature from 5 to 10 deg. in this way, depending upon the outside humidity, it results in the admission of air to the room at a relative humidity of about 85 per cent, which at temperatures of 75 to 80 deg. will prove oppressive. When spray water is available at a temperature of 55 deg., the air may be cooled from 15 to 18 deg., under the same conditions as previously noted and without the absorption of moisture, as the cooling is done by the direct transmission of heat from the air to the spray water, which also results in removing a portion of the moisture from the air under certain conditions. When cold water is not available from deep wells at small expense, a refrigerating coil may be placed either in the spray chamber or the tank of the washer. Air at a temperature of 85 deg. and 70 per cent relative humidity contains 1.282 lb. of moisture per 1,000 cu.ft. To cool this volume of air per minute to a temperature of 75 deg. and condense sufficient moisture to reduce the humidity to 60 per cent at the lower temperature (0.808 lb. per 1,000 cu.ft.) will require a refrigerating capacity of about 5 tons per 24 hours, or an ice-melting effect of $2{,}000 \times \frac{5}{24} = 416$ lb. per hour.

Air washers may be equipped with refrigerating coils at a comparatively small expense, and when connected with an absorption refrigerating machine operated with exhaust steam which would otherwise be wasted in the summer, the running cost is very small. The best type of equipment to use in any given case, and the amount of cooling that may be profitably employed artificially, can be approximated by use of the foregoing data.

Humidity-Control Methods

In plants employing hot-blast heating, humidity control is easily obtained by the use of an air washer equipped with the necessary devices for automatic regulation. The required amount of evaporation is produced by heating the spray water, a special steam heater either of the jet or closed type being used, depending upon the available pressure.

In some cases the quantity of steam admitted to the heater is controlled directly by a humidostat placed in the air current as it leaves the fan or reheater, this being a device acted upon by the amount of moisture in the air. In other cases the regulating valve of the spray heater is controlled by a thermostat placed between the eliminators and the reheater, which maintains a predetermined temperature of the air leaving the washer. For example, suppose it is desired to deliver air to a building at a temperature of 68 deg. and 47 per cent humidity, which we see from the table corresponds to an ideal wet-bulb temperature of 56 deg. We first note from the table that air under these conditions contains 0.506 lb. of moisture per 1,000 cu.ft. We also find from a more complete psychrometric table that air at a temperature of 46 deg. when fully saturated (relative humidity 100 per cent) contains practically the same amount of moisture (actually 0.510 lb. per 1,000 cu.ft. of air). Hence, the thermostat would be set for 46 deg. and the air coming in contact with the warm spray would become saturated and leave the washer in this condition, carrying with it the required amount of moisture, or 0.510 lb. per 1,000 cu.ft. Raising the temperature after this, to 68 deg. by passing through the reheater, does not alter the amount of moisture, but does reduce the *relative* humidity to 47 per cent. During the summer season fresh air is admitted without heating and the humidity must be taken as it occurs, except in special cases where dehumidifying is necessary for special industrial processes. As the excessive dryness of the inside air in the winter season is due largely to heating it without adding moisture, natural conditions are much better during the summer when no heat is required. When it is not convenient to employ an air washer, as in case of buildings heated by direct radiation, the moisture may be delivered to the air of the room in the form of a fine spray or mist, there being a number of special devices for this purpose. Perforated steam pipes, covered with suitable material are sometimes used for humidifying. The excess of moisture in certain departments of manufacturing plants, like dyehouses, etc., is best removed by the introduction of large volumes of outside air, warmed to a temperature of about 70 deg. This should be delivered at the lower part of the room, near the surface of the liquid giving off the vapor, where it becomes nearly saturated, and is then taken away through exhaust openings in or near the ceiling (see Fig. 4). Jets of warm dry air should also be blown over such surfaces as are likely to condense the moisture and cause dripping. Small isolated sources of steam may usually be cared for by means of hoods connected with a strong outward draft.

Air Movement and Velocity

In general, the air velocity over people at rest or engaged in light work should not exceed 120 ft. per minute. In some cases, where both the temperature and humidity are high, and the occupants actively engaged, considerably higher velocities may be allowed without discomfort or danger.

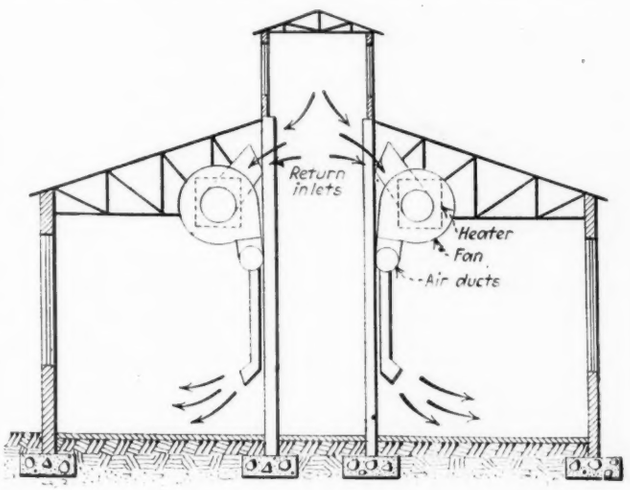


FIG. 5. VENTILATION DIAGRAM FOR MONITOR-ROOF BUILDINGS

In a well-designed fan system there should be no difficulty in obtaining the necessary air movement without drafts by the proper arrangement and form of inlets.

In the case of direct heating the circulation may be greatly improved by the use of electric fans of the desk type. Unit heaters, which are becoming quite com-

mon for the warming of industrial buildings, are effective in the matter of air movement and distribution. The design of most of these is such as to withdraw the cooler air from near the floor and discharge it, after warming, at a higher level. In buildings of the monitor-roof type, where heated air tends to collect in the upper part, the arrangement may be reversed; that is, air is drawn from the under-roof space and discharged near the floor. This plan is especially adapted to hot-blast systems originally designed to take their air supply from out of doors. The principle of this method is shown diagrammatically in Fig. 5.

Recirculation of Air

The ability to recirculate the air within a building equipped for hot-blast heating is an important matter in its relation to the fuel problem, as it practically halves the heat requirements in severe weather. Where there is ample space per occupant, excellent atmospheric conditions may usually be secured by recirculating the air through a washer and returning it to the building, thus saving the heat that it contains. The impurities to be got rid of consist of dust and accompanying bacteria, together with disagreeable odors whether from the bodies of the occupants or from industrial processes, or both, as the case may be. These are largely removed by air washing, thus eliminating the necessity of admitting outside air for dilution or reducing it a substantial amount, according to conditions. In buildings like machine and erecting shops, heated by direct radiation, natural leakage, assisted by open windows in mild weather, will usually keep the air in good condition when dust and odors are removed at their source by an effective exhaust system. To this should be added careful temperature control, and humidification in such cases as are found necessary.

Ozone is a modified form of oxygen which is extremely unstable so that it rapidly oxidizes, or burns up, any organic matter with which it comes in contact, It is formed from the oxygen of the air as it passes through an electrical discharge, and its presence is often noticed after a severe thunder storm from the slight odor which accompanies a strong concentration. In the practical application of ozone to ventilation it is produced artificially by passing air through concentric tubes between which exists an electrical discharge. The ozone thus liberated is either mixed with the air from the main supply fan or diffused by means of a small disk fan attached to a portable ozonator placed in the room to be treated.

Ozone is used for two purposes, first for destroying offensive odors, and second, as a preventer of fatigue. When supplied in just the right amount it has the effect of producing a refreshing exhilaration without any of the depressing after-effects which follow the ordinary stimulant. It is known to give relief from excessive heat, but just why this is so is not clearly understood at the present time. Ozonators ranging from the household size up to those having a capacity of 25,000 cu.ft. of air per minute are now manufactured in practical form for general ventilating purposes.

Dust Removal and Prevention

The removal of dust is given special importance in the newer ideas regarding ventilation. This is because dust in itself is irritating to the respiratory passages and is also a carrier of bacteria. The best method of dealing with street dust, soot, etc., is to keep the windows closed and draw in a supply of outside air through a washer, or recirculate the air within the building, depending upon the season of the year and the character of the work carried on within it. Dust produced inside should be taken care of at the source, so far as possible, by the use of hoods connected with a strong exhaust draft. This applies especially to grinding, polishing, the cleaning of castings, and various processes in shoe and woodworking shops, textile mills, etc. In cases where fine dust must necessarily become diffused throughout the room, general exhaust ventilation will be required, the air either being discharged outboard or washed and returned to the building.

Fumes from chemical or other processes should be treated in practically the same manner as dust, first by exhaust hoods and second by general room ventilation.

Miscellaneous Examples

It may be well to give a few practical examples illustrating the use of the wet-bulb thermometer, the table and the curves shown in Fig. 2.

Example 1: In a room where the occupants are engaged in light work, the psychrometer shows a dry-bulb temperature of 74 deg. and a wet-bulb of 52 deg. Furthermore, suppose the nature of the work is such that the air must be kept practically quiet. What changes should be made to make the atmospheric conditions more comfortable? From the curve for light work, and no air motion, in Fig. 2, we find the ideal wet-bulb temperature should be between 54 and 55 deg. Also, from the table we find the air of the room much too dry, having a relative humidity of only 16 per cent for a temperature of 74 deg. and a wet-bulb of 52 deg.

More comfortable conditions may be secured by lowering the room temperature to 70 deg. and adding moisture until the wet-bulb rises to 55 deg., which calls for a relative humidity of 37 per cent.

Example 2: A certain mechanical process requiring light exertion must be carried on in air having a relative humidity of 70 per cent. What room temperature will prove the most comfortable? Assuming that an air movement of 120 ft. per minute is permissible, by the use of electric fans, we find the curve for "light work" in Fig. 2 calls for an ideal wet-bulb temperature of 58 deg. for this velocity. Looking in the table, we find that a room or dry-bulb temperature of 64 deg. and a relative humidity of 70 per cent gives a wet-bulb temperature of 58 deg. Hence, a room temperature of 64 deg. will give the greatest comfort to the occupants under the required conditions.

Example 3: A room commonly kept at 74 deg. has a wet-bulb temperature of 60 deg. and is found somewhat oppressive. As there is no way of removing moisture from the air, how may conditions be bettered?

For the greatest comfort in still air, with the occupants at rest, the wet-bulb temperature should be 56 deg. In the present case, air at 74 deg. dry-bulb and 60 deg. wet-bulb contains 0.574 lb. of moisture per 1,000 cu.ft. and cannot well be changed.

If the air is given the moderate movement of 70 ft. per min., a wet-bulb temperature of 58 deg. will be called for, and if the room temperature is lowered to 68 deg., the moisture normally contained in the air will give very nearly this result.

Problems involving different conditions may be worked out in a similar manner by the use of the table and curves.

Temperature of Controllers*

By H. D. JAMES
Manager, Industrial Control Department, Westinghouse Electric and Manufacturing Company

THE temperature of a controller depends upon a number of factors. If the controller is inclosed without ventilation, the heat must be radiated from the outside of the inclosure. In such cases it will be found that the temperature inside the box is increased if the contactors rupture the arc frequently. If the starting resistors or auto-transformers are in this

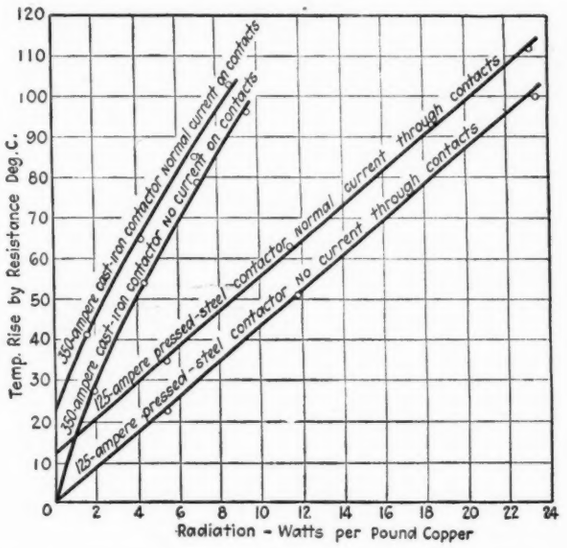

Temp. Rise by Resistance Deg. C.
Radiation - Watts per Pound Copper
350-ampere cast-iron contactor normal current on contacts
350-ampere cast-iron contactor no current on contacts
125-ampere pressed-steel contactor normal current through contacts
125-ampere pressed-steel contactor no current through contacts

FIG. 1. TEMPERATURE CURVES OF MAGNETIC CONTACTOR OPERATING COILS

inclosure, frequent starting will raise the temperature. Magnetic contactor coils should be tested at rated voltage and with rated current flowing through the main contact parts. Tests have been made on contactors with normal current passing through the contacts and the voltage on the operating coil varied to obtain the radiating characteristic of the coil. The tests were then repeated without current in the main contacts, which resulted in a lower temperature of the operating coil, Fig. 1. Tests have also been made on the operating coil at rated voltage and various currents passing through the main contacts. These tests all show the close relation that exists between the temperature of the shunt operating coil and the current carried by the main contacts. The writer recalls a large contactor in which a mistake had been made in the shunt. Tests showed that this shunt ran about 30 deg. C. above normal, and the coil temperature measured by resistance was 10 deg. C. high. When the shunt was made of the proper size, the same operating coil showed a normal temperature rise.

The temperature of a controller is limited in order to protect the insulation from injury and, where the parts are exposed to persons, to protect them from being burned. In some cases, like that of a resistor, the temperature is limited by the fire risk.

In specifying the temperature of any part of a control equipment, the nature and location of the insulating material should be considered, and there should be a reasonable factor of safety between the temperature to which the insulation is subjected and that at which rapid deterioration sets in. There are certain portions of a contactor—for instance, the blowout coil—that can be safely run at a much higher temperature than other parts. In fact, this coil is adjacent to the arc-rupturing part of the contactor and must have refractory insulation. Resistor grids are limited by standard practice to a hot-spot temperature rise of 350 deg. C. This is slightly below a dull-red heat and leaves a considerable factor of safety.

The shading coil on an alternating contactor usually gets quite hot and must, therefore, be located so that it will not injure the operating coil, Fig. 2. This shows five sizes of magnet contactors designed for operation on alternating-current circuits. Each contactor has two poles, the arc boxes are provided with arc splitters, and rolling contacts are used. Note the location of the shading coils at top of the armature. This location keeps the shading coil outside and away from the operating coil so that its temperature does not increase the temperature of the operating coil.

Where it is desirable to have more than the normal factor of safety in a controller, it should be expressed as a percentage of load current or line voltage. For instance, a contactor might be specified to meet the standard guarantees when tested at 150 per cent of normal rated current and 10 per cent above normal voltage. In this case a larger-sized controller would be

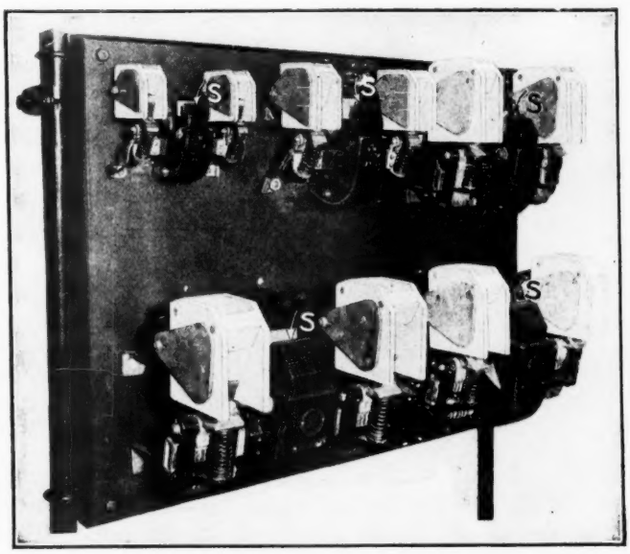


FIG. 2. ALTERNATING-CURRENT CONTACTORS

supplied. It is very difficult for an experienced designer to proportion a contactor so as to obtain a new set of temperatures at normal load and voltage unless he has test data on which to base these deductions. It is, therefore, quite difficult for engineers, unfamiliar with this apparatus, to select a new set of temperatures.

Some applications require more than the ordinary factor of safety, and engineers responsible for such installations often try to express this by fixing a definite temperature at which the contacts, operating coils

*All rights reserved.

and other parts of the control structure shall operate. This gives an increased factor of safety, but often at an expense out of proportion to the results accomplished, and the increase in factor of safety is unknown to the person specifying such temperatures, as they are not ordinarily based on actual test data. For instance, a reduction of 10 deg. C. in the operating temperature of a contact might mean a very small factor of safety in one design and a large factor of safety in another design, due to the effect that other current-carrying parts have on the contacts. Sometimes specifying a particular temperature for some part of the control forces the use of an abnormal structure.

If the factor of safety is expressed in terms of an overload, as previously suggested, logical deductions can be made and the proportions of a given design are retained. In specifying the strength of a steel bar, the factor of safety is usually expressed as a certain percentage of the elastic limit. Therefore it would seem logical that the factor of safety of the controller should be expressed in terms of the overload that it will carry at normal temperature.

Resistors are very common and, in general, well understood by operating engineers. There are a few fundamentals that might be considered. It is recognized that the resistor is used for the purpose of absorbing energy during the starting of a motor or when the speed is regulated. This energy is converted into heat which must be radiated. Small motors develop so little heat during starting that the construction of the controller usually provides sufficient protection from surrounding objects and no additional precautions are

ELECTRIC POWER CLUB RESISTOR CLASSIFICATION TABLE

Per Cent Full Load Current First Point	Starting Torque in Percentage of Full Load: Series Motors	Compound Motors	Shunt Motors	Wound-Rotor Induction Motors	Resistor Class Number — Starting Duty: Light, 15 Seconds on, Out of 4 Min.	Heavy, 30 Seconds on Out of 4 Min.	Speed Regulation Interm't Duty: Light, 1 Minute on, Out of 4 Min.	Heavy, 2 Minutes on, Out of 4 Min.	Speed Regulation Continuous Duty
25	8	12	25		11	31	51	71	91
50	30	40	50	30	12	32	52	72	92
70	50	60	70	50	13	33	53	73	93
100	100	100	100	100	14	34	54	74	94
150	170	160	150	150	15	35	55	75	95
200	250	230	200	200	16	36	56	76	96

required for installation. Unfortunately, this question of radiation is sometimes overlooked on large motor installations, and the resistance is packed together too close and in a structure or a part of a room that does not permit sufficient ventilation. Where the resistor consists of a number of frames, these frames should not be piled more than three high and should be so distributed that the heating is divided between the different tiers or piles of grids. As an example a portion of the grids may be used for starting and the remainder for regulating the speed. The starting resistors are in circuit only a short time and should be distributed among the different tiers, preferably at the bottom. The resistors in the last step will be in circuit the longest and should be located on the top of the different piles.

In specifying resistors, confusion may arise because of the terms used in describing the service. In order to avoid this and make it easy to specify resistors, the Electric Power Club has prepared a classification given in the table. Each horizontal line corresponds to a different percentage of full-load current when all of the resistor is in circuit. The vertical columns on the right-hand side of the table give the Electric Power Club classification numbers corresponding to the different classes of service. Other vertical columns have been added showing the percentage of full-load torque that standard motors will develop at the current value given in the first column. These torques will differ somewhat with various designs of motors, but the figures given may be considered as representative of an average design and are useful for reference. This classification provides a ready means for a user to pick out quickly the classification number corresponding to his requirements. This method of specifying resistors has been in use for several years and has proved very convenient.

The Specific Volume of Dry Steam

BY M. J. EICHHORN

The Callendar formula for the specific volume of dry steam can be put in the following form:

$$v = 1.07061\,\frac{T_c + 273.1}{p_1} - \frac{1.2014}{\left(\frac{T_c}{273.1} + 1\right)^{10/3}} + 0.016$$

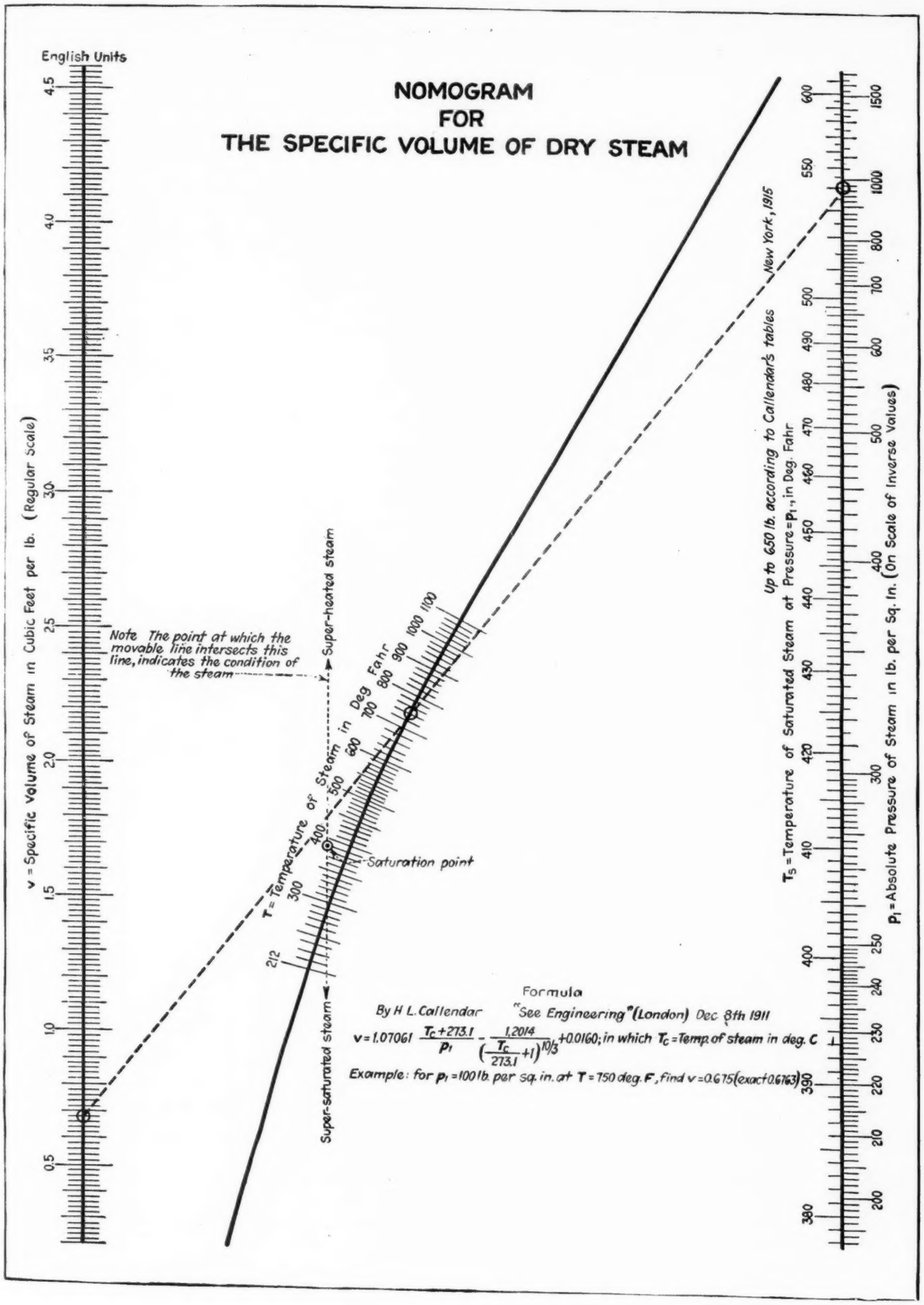
in which v is the specific volume of steam in cubic feet per pound, p_1 is the absolute pressure of steam in pounds per square inch, and T_c is the temperature of steam in degrees Centigrade. When considered from the viewpoint of nomography, the equation is seen to be of the form,

$$f(v) = f_1(T) \cdot f_2(p_1) - f_3(T)$$

and consequently it may be represented by means of two straight scales and a curve, the straight scales being graduated according to the functions $f(v) = v$, and $f_2(p_1) = \frac{1}{p}$. The latter is a scale of inverse values, as shown in the chart on the opposite page, and on this scale for p_1 has been plotted the temperature scales, as already outlined. Once the base scales for v and p_1 have been established, it is a simple matter, though involving a considerable amount of tedious numerical computation, to get a sufficient number of pairs of these quantities, by substituting in the equation an arbitrary value of T, reducing, and then substituting a pair of arbitrary values for p_1, thus obtaining a pair of solutions for v, which determine one point on the curve for T, as well as the numbering of the same.

This nomogram is read in the same manner as the preceding ones, by means of a movable straight line, and it is a remarkable fact that if any two values of v and p_1 for saturated steam are joined by a straight line, all these lines will pass through one and the same point, at least for the pressure range represented in the chart, in which this point has been designated as the "saturation point." Also a line parallel to the outside scales has been drawn through this point, and if the movable line intersects the latter line to the right side of the "saturation point," then the condition of the steam is superheated; if on the left side, then the steam is supersaturated. The dotted line indicates the specific volume at 750 deg. F. and 1,000 lb. per sq.in. to be 0.6763, which is entirely discordant with the value $v = 0.7218$ obtained from Knoblauch's formula, which was used for the calculation of Marks and Davis' tables. The formula of Goodenough, published in "University of Illinois Bulletin" No. 75, also gives a result, confirming the latter value of v.

*See *Power*, May 17; June 7, 1921.


English Units
NOMOGRAM
FOR
THE SPECIFIC VOLUME OF DRY STEAM
v = Specific Volume of Steam in Cubic Feet per lb. (Regular Scale)
Note The point at which the movable line intersects this line, indicates the condition of the steam
Super-heated steam
T = Temperature of Steam in Deg Fahr
Saturation point
Super-saturated steam
Up to 650 lb. according to Callendar's tables New York, 1915
T_S = Temperature of Saturated Steam at Pressure = p_1, in Deg. Fahr
p_1 = Absolute Pressure of Steam in lb. per Sq. In. (On Scale of Inverse Values)
Formula
By H L. Callendar "See Engineering" (London) Dec. 8th 1911
v = 1.07061 (T_c + 273.1)/p_1 - 1.2014/((T_c/273.1)+1)^10/3 + 0.0160; in which T_c = Temp. of steam in deg. C
Example: for p_1 = 100 lb. per sq. in. at T = 750 deg. F., find v = 0.675 (exact 0.6763)

Draft and Its Production and Measurements*

By TERRELL CROFT

THE function of draft is to force air to the fire and to carry away the gaseous products of combustion. Proper combustion in a furnace can occur only when an ample quantity of oxygen, which is contained in the air, is supplied to the burning fuel. If the supply of oxygen is insufficient, the combustion will be sluggish and inefficient, even with super-refined furnace construction and the most skillful stoking.

A definite meaning for the word "draft" has not been established rigidly. Draft is understood universally to relate to the movement of gases through a furnace, boiler and chimney, but sometimes it is used to indicate the volume of the gases moved. Again, it is employed frequently to denote the air pressure that produces the movement. In this article "draft" will designate the quantity of air that is forced through a furnace in a given time. The term draft pressure will imply the pressure that causes the gases to move. The draft may be ample, when sufficient air is supplied to the furnace for combustion, even though the draft pressure is small, as shown by a draft-pressure gage which reads only a ½-in. water column.

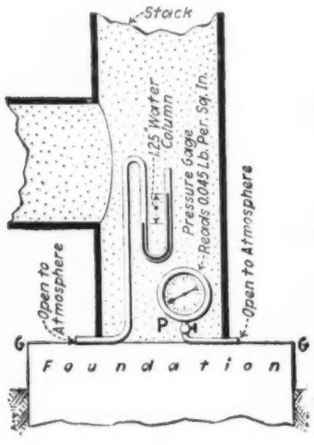


FIG. 1. PRESSURE GAGE INSIDE STACK

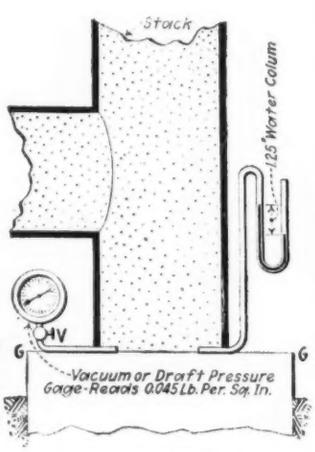


FIG. 2. VACUUM GAGE OUTSIDE STACK

Chimney draft is due to a pressure as indicated in Figs. 1 and 2. The impression that it is due to a vacuum is erroneous. A draft-pressure gage reading (Fig. 3) indicates the tendency or pressure of the cold outside air to force its way into the furnace, boiler setting, breeching or chimney.

Draft pressure may be produced either naturally or artificially. Chimney, or natural draft only will be considered here. Natural draft is produced by the natural draft of a chimney. Artificial draft may be obtained by a steam jet either induced or forced, and mechanical draft by a fan or blowing machine either induced or forced.

The function of a chimney is twofold: It produces draft pressure, whereby the draft is forced through the furnace, fuel and setting. The air which carries the oxygen necessary for the proper burning of the fuel is thereby furnished to the fuel bed. It also carries the products of combustion to such a height, before discharging them, that they may not be objectionable or injurious to surroundings.

The basic principle of natural- or chimney-draft pressure is that when a lighter gas is submerged in a heavier one, the lighter gas is forced upward by the heavier. A hot-air balloon ascends in the cooler atmosphere; similarly, a cork which is submerged in water rises. It is due to the same fundamental causes that a chimney produces the draft pressure which forces the draft through the boiler furnace and setting.

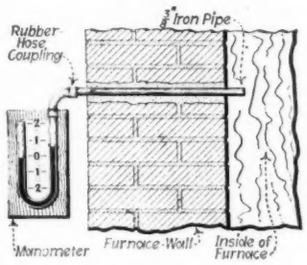


FIG. 3. MANOMETER DRAFT GAGE

How a chimney produces a draft pressure may be understood from a consideration of Figs. 4, 5 and 6. In Fig. 4 stacks *C* and *H* are of identical dimensions and construction. The area *CG* is filled with air at the same temperature as that of the surrounding atmosphere. The area *HF* is filled with hot air. The volume of hot air in *H*, because of its lower density, weighs less than the equal volume of cool air in *C*. The equal cool-air columns A_1 and A_2, each extending vertically upward to the limit of the atmosphere, counterbalance each other. Hence, the heavy volume *C* tends to force the lighter volume *H* up out of the stacks. Thus a pressure is exerted against the partition *P*. The force, in pounds, imposed against *P* equals the pounds weight of *C* minus the pounds weight of *H*. Neither the volume of hot air in the horizontal passage *F* nor that of cool air in *G* is a factor in the problem, since neither increases the vertical heights of the air columns. If *CG* were removed and the entering cool air were continuously heated in F_1, Fig. 5, a continuous current

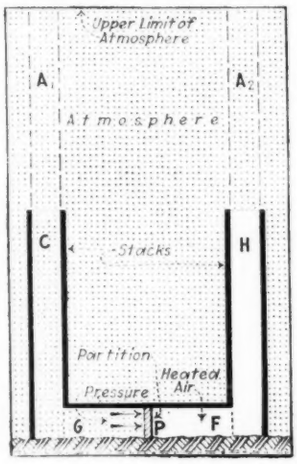


FIG. 4. PRINCIPLE OF CHIMNEY DRAFT

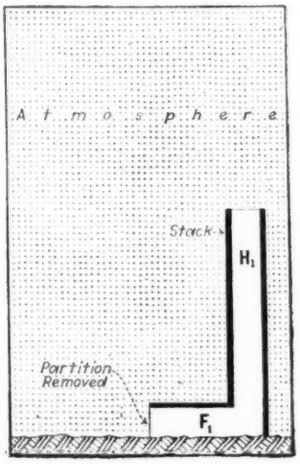


FIG. 5. FURNACE AND STACK

*All rights reserved. This material constitutes a portion of the author's forthcoming book, "Steam Boilers."

of air would, obviously, be forced upward through F_1H_2. The removal of the stack CG, Fig. 4, has not, since CG contained only air at atmospheric temperature, affected the elements of the situation. Fig. 6 illustrates the application of the principle to a boiler and stack. In this instance the pounds draft pressure impressed against the grate equals the amount of cool air in pounds in the column D minus the weight in pounds of hot air in the column B. D and B both have the same cross-sectional area. The height of the columns B and D is the vertical distance between the top of the stack and the bottom of the grate. Draft pressure is measured in inches of water column in practice, because this is the most convenient unit. It could, if desirable or convenient, be measured in any unit of pressure per unit area such as pounds per square inch. A draft-pressure gage reading of 2 in. water column means that the draft pressure tending to force the outside air into the stack or boiler, at the point at which the reading is taken, is just sufficient to support a column of water 2 in. high.

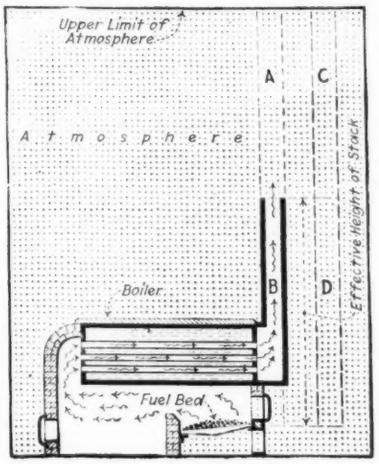


FIG. 6. DRAFT-PRESSURE PRINCIPLES AS APPLIED TO A BOILER

An elementary manometer or draft-pressure gage, Fig. 3, is merely a glass tube of any convenient diameter and having a "U" bent in one end. The U-portion is partly filled with water. One end of the tube is connected to the inclosed space the draft pressure of which it is desired to measure. The other end is open to the atmosphere. When there is no difference in pressure between the two ends of the tube, the water will rest at the same level in both legs (Fig. 7, *I*). If the atmospheric pressure tends to force air into the inclosed space, the water in the leg which connects into the space is forced up as at *II* and *III*, correspondingly. The weight of the cool-atmosphere column W_A, Figs. 8 and 9, acts against the weight of the lighter, hot-air column and forces it up until the unbalanced height of the water column just equals the difference in the weights. The total draft pressure, sometimes called the theoretical maximum static draft pressure, developed by a chimney is the total pressure that results, due to the difference in the weights of the

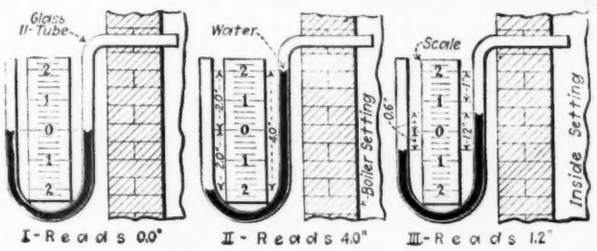


FIG. 7. EXAMPLES IN READING MANOMETER DRAFT GAGE

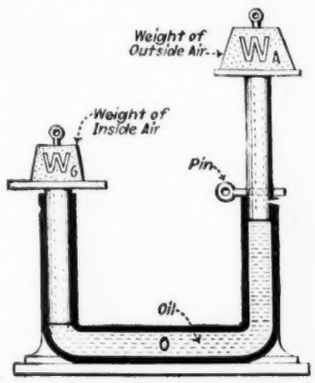


FIG. 8. PRINCIPLE OF DRAFT

TABLE I. SHOWING CHIMNEY DRAFT PRESSURES, DRAFT-PRESSURE DROP AND AVAILABLE DRAFT PRESSURE

(The values in this table have been computed for an imaginary exaggerated set of conditions, Figs. 10 and 11, to illustrate the principles involved)

I Element of Flue Gas Path		Draft-Pressure Gages: II Identifying Letter	Draft-Pressure Gages: III Assumed Height of Exploring Tube Above Grate (Ft.)	*IV Elevation Draft Pressure (Inches Water Column) Due to Hot Gas Column	Ash Pit Door Open (All Values in Inches Water Column): Drop in Draft Pressure Due to Friction and Velocity: V Between Successive Tube Locations	Ash Pit Door Open: Drop in Draft Pressure Due to Friction and Velocity: VI Total up to Designated Locations	Ash Pit Door Open: Available Draft Pressure: VII Between Successive Tube Locations	Ash Pit Door Open: Available Draft Pressure: VIII Total up to Designated Location VIII-IV-VI	Identifying Letter
Outside		A	0.0	1.250				0.000	A
Boiler	Ashpit	B	0.0	1.250	a to b —0.010	1.250	a to b +0.010	0.010	B
Boiler	Furnace	C	5.6	1.215	b to c —0.440	1.240	b to c +0.405	0.415	C
Boiler	End 1st pass	D	16.0	1.150	c to d —0.130	0.800	c to d +0.065	0.480	D
Boiler	End 2d pass	E	0.0	1.250	d to e —0.130	0.670	d to e +0.230	0.710	E
Boiler	End 3d pass	F	16.0	1.150	e to f —0.130	0.540	e to f +0.030	0.740	F
Boiler	Inside damper	G	16.0	1.150	f to g —0.010	0.410	f to g +0.010	0.750	G
Breeching		H	16.0	1.150	g to h —0.015	0.400	g to h +0.015	0.765	H
Breeching		I	16.0	1.150	h to i —0.014	0.385	h to i +0.014	0.779	I
Breeching		J	16.0	1.150	i to j —0.014	0.371	i to j +0.014	0.793	J
Breeching		K	23.6	1.102	j to k —0.065	0.357	j to k +0.017	0.810	K
Breeching		L	29.2	1.067	k to l —0.065	0.292	k to l +0.030	0.840	L
Breeching		M	29.2	1.067	l to m —0.014	0.227	l to m +0.014	0.854	M
Chimney	Active	N	29.2	1.067	m to n —0.000	0.213	m to n +0.000	0.854	N
Chimney	Active	O	50.0	0.937	n to o —0.030	0.213	n to o —0.100	0.754	O
Chimney	Active	P	75.0	0.781	o to p —0.031	0.183	o to p —0.125	0.629	P
Chimney	Active	Q	100.0	0.625	p to q —0.030	0.152	p to q —0.126	0.503	Q
Chimney	Active	R	125.0	0.469	q to r —0.031	0.122	q to r —0.125	0.378	R
Chimney	Active	S	150.0	0.312	r to s —0.030	0.091	r to s —0.127	0.251	S
Chimney	Active	T	175.0	0.156	s to t —0.031	0.061	s to t —0.125	0.126	T
Chimney	Active	U	200.0	0.000	t to u —0.030	0.030	t to u —0.126	0.000	U
Chimney	Inactive	V	0.0	1.250	u to v +0.213	0.000	u to v +1.037	1.037	V
Chimney	Inactive	W	16.0	1.150	v to w —0.000	0.213	v to w —0.100	0.937	W
Chimney	Inactive	X	25.0	1.094	w to x —0.000	0.213	w to x —0.056	0.881	X
Chimney	Inactive	N	29.2	1.067	x to m —0.000	0.213	x to m —0.027	0.854	N

* Since the total draft pressure developed by this 200-ft. high chimney is 1.25 in., the drop due to decreasing height of flue-gas column, per foot height, is 1.25 ÷ 200 = 0.006,25 in. water column.

It is here assumed that the inactive portion of the chimney contains flue gases at the same temperature as that of those in the active portion.

column of hot flue gas inside the chimney and a column of the outside air of the same area and height. The intensity of draft pressure will be indicated by a draft-pressure gage, which is located at the grate level, when the ashpit door is closed and no flue gases are flowing. In Fig. 10 and Table I, column IV (which will be discussed later), the total pressure is 1.25 in. water column, as indicated by gages *B*, *E* and *V*. Fig. 11 shows conditions with the ashpit door open.

The formula for computing the chimney height necessary for the development of a given draft pressure is stated below. The formula is merely an expression for the difference in weight of unit columns of hot chimney gas and of cool outside air, reduced to unit pressure, in inches water column:

$$P'_h = 0.52\, L_h P_2 \left(\frac{1}{T_O + 460} - \frac{1}{T_G + 460} \right) \quad \begin{matrix} (\textit{total draft} \\ \textit{pressure, inch water column}) \end{matrix} \qquad (1)$$

or,

$$L_h = \frac{P'_h}{0.52\, P_2 \left(\frac{1}{T_O + 460} - \frac{1}{T_G + 460} \right)} \quad (\textit{height, feet}) \qquad (2)$$

where,

P'_h = Intensity of draft pressure, in inches water column, exerted at the base of the chimney, or portion thereof, of height L_h.

L_h = Height of the chimney, or portion thereof, under consideration, in feet.

P_2 = Pressure of the atmosphere at the altitude at which the chimney is installed, in pounds per square inch = 14.7 lb. per sq.in. at the sea level.

T_O = Average temperature of outside air, in deg. F. (usually taken, in the temperature zone, as about 60 to 65 deg.).

T_G = Average temperature of chimney gases, in deg. F. (usually taken as about 500 to 600 degrees).

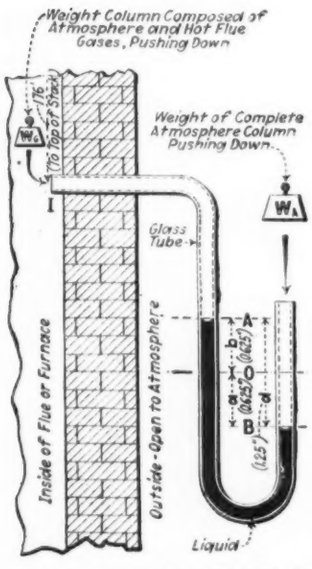

Weight Column Composed of Atmosphere and Hot Flue Gases, Pushing Down
To Top of Stack
Weight of Complete Atmosphere Column Pushing Down
Glass Tube
Inside of Flue or Furnace
Outside - Open to Atmosphere
Liquid

FIG. 9. PRINCIPLE OF MANOMETER DRAFT GAGE

The height of a chimney determines the draft pressure which it will develop under given altitude and outside-air and flue-gas temperature conditions. To develop a certain draft pressure, a chimney should be the same height regardless of the number of boilers it serves. But the greater the number of boilers served (the greater the amount of coal burned) the greater the flue area should be. There is a drop in draft pressure when flue gases flow in a chimney. When the ashpit door is closed (when there is no flue-gas flow) there is no drop. Under this condition, assuming that the setting and chimney are airtight, a draft-pressure gage *B*, Fig. 10, which is located at the grate level, will read the total draft pressure that the stack develops. This is shown as 1.25 in. water column. When flue gases are flowing, the grate-level draft-pressure-gage reading *B*, Fig. 11, will, because of drop, be less than the total pressure; it is shown as 0.01 in. Probable values of drop in chimney-draft pressure may be predicted, as explained hereinafter, by using data in Table II, which are based on experience. Draft-pressure drop is a loss in draft pressure which is caused by: (1) The frictional resistance offered by the interior surfaces of the chimney and gas passages to the flue-gas flow (columns V and VI in the Table I); (2) the imparting velocity to the flue gases (columns V and VI). In chimney-design practice, cause 2 is usually negligible. Hence, in Table I causes 1 and 2 are combined.

The available draft pressure at any location along the flue-gas path is the draft pressure that is unexpended, remaining or available at that location. Draft-pressure gages indicate available draft pressures. To obtain the available draft pressure at any point along the flue-gas path, subtract from the total draft-pressure developed by the stack at that location the total draft-pressure drop up to that point.

In Table I (see also Fig. 11) the total drops are given in column VI. In column VII the available draft pressures are recorded. The available draft pressure (that is, the draft-pressure gage reading) at any location equals the total draft pressure at that location minus the total drop to that location. Thus, at location *G* the available draft pressure equals 1.150 minus 0.400 equals 0.750 in. water column.

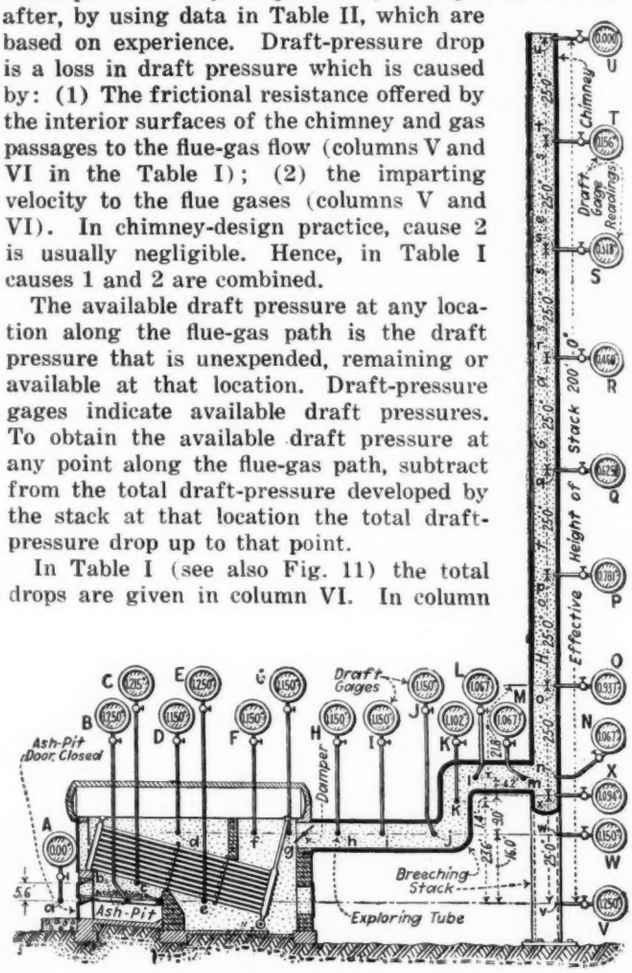


FIG. 10. DRAFT-GAGE READINGS FOR BOILER SETTING AND STACK WITH FIREDOORS CLOSED AIRTIGHT

TABLE II. APPROXIMATE DROPS IN AVAILABLE DRAFT PRESSURE IN PRACTICE

No.		Element of Flue-Gas Path	Approximate Available-Draft Drop In Inches Water Column
1		Ashpit	Often disregarded. Should not exceed 0.01 in.
2	Boiler	Fuel bed and furnace	Depends on kind and size of coal, pounds burnt per hour, design of furnace, etc. For typical values, see Fig. 12
3	Boiler	(a) First pass	Depends on: (1) Type of boiler; (2) method of baffling. May vary between 0.10 and 1.00 in.
4	Boiler	(b) Second pass	
5	Boiler	(c) Third pass	Often assumed to be about 0.40 in. total, from furnace to through last pass
6	Smoke Conduit (Breeching)	Straight runs	Unlined sheet steel, 0.001 in. per foot length. Brick or masonry, lined, 0.002 in. per foot length.
7	Smoke Conduit (Breeching)	Turns or elbows	Each right-angle turn, unlined steel or masonry, lined, 0.05 in.
8	Smoke Conduit (Breeching)	Damper	Small. Can usually be disregarded.
9	Smoke Conduit (Breeching)	Economizer	Varies over a considerable range. Ordinarily is between 0.10 in. and 0.25 in.
10		Chimney	Is actually about, and in practice is assumed to be equal to 20 per cent of the Total Draft Pressure developed by the chimney, or by the portion of the chimney under consideration.

Drop in available draft-pressure is the drop or decrease in the available pressure at successive locations

along the flue-gas path. It may be obtained by taking the difference between the draft-pressure-gage readings at those locations. Table II shows approximate drops in pressure along the flue-gas path and are based on draft-pressure-gage readings observed in operating installations.

Table I indicates the approximate drops in available draft pressure that may be expected in practice. The values shown are averages of many determinations. While, in usual cases, drops differing widely from those tabulated may be encountered, the values given are, ordinarily, sufficiently accurate for estimating the height of a chimney required to satisfy a given set of conditions. The values given are for normal boiler load on the basis of the boiler rating. The drops increase as the load that the boiler is carrying increases.

The drop in available draft pressure through any element of a flue represents the draft necessary to force the flue gases through that element. Hence, to determine the effective, or net, draft pressure that a chimney for a given installation must produce at its base, it is merely necessary to add together the available-draft pressure

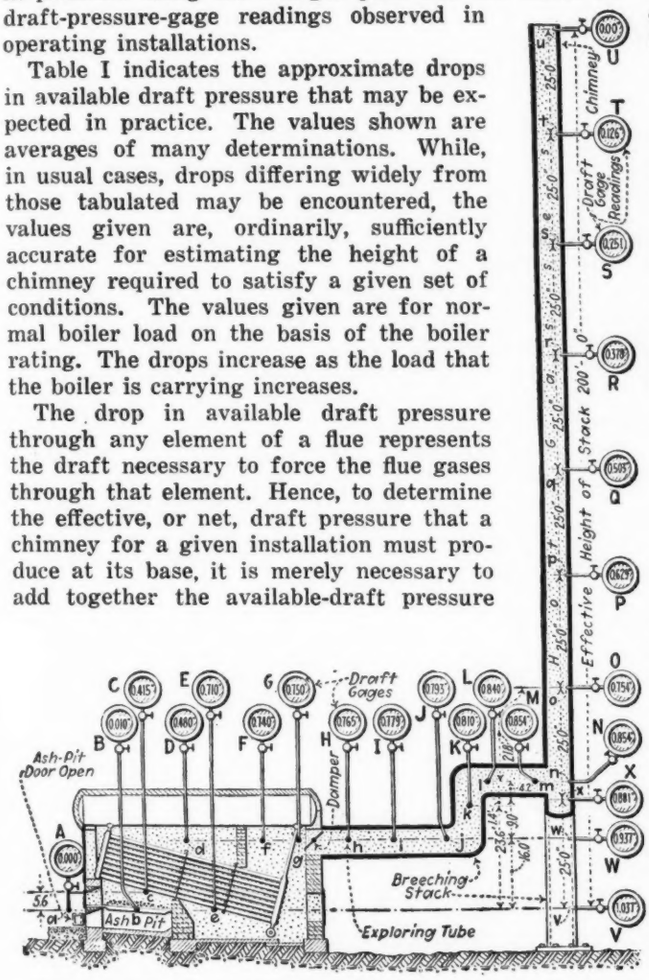


FIG. 11. DRAFT-GAGE READINGS IN A SPECIFIC CASE WITH ASHPIT DOORS OPEN

drops through the furnace, setting and smoke conduit. Their sum, in inches water column, will be equal to the net, or effective, draft pressure that the chimney must develop.

Smoke-conduit connection is the location where the smoke conduit from the boiler or boilers joins the chimney. In Fig. 11 the smoke-conduit connection is at *m*.

The effective draft pressure of a chimney is the available draft pressure developed by the chimney at the smoke-conduit connection when the flue gases are flowing. It is that portion of the total draft pressure developed by the chimney from the smoke-conduit connection upward, which is not lost in the chimney in overcoming friction and in imparting velocity to the flue gases. Therefore, it is the draft pressure that is effective in forcing the flue gases through the boiler and smoke conduit. The effective draft pressure equals the total draft pressure at the smoke-conduit connection minus the drop in draft pressure in the chimney, from the smoke-conduit connection upward.

A chimney in action is analogous to a vertical tube *TE*. Fig. 13, along which operating centrifugal pumps are arranged, the whole being submerged in a vessel of water. The water in the vessel is analogous to the atmosphere. The hydraulic pressure developed by the pumps is analogous to the draft pressure developed by the hot gases in a chimney. The current of water circulated through *AET* by the pumps is analogous to the flue gases that are circulated by a chimney. The avail-

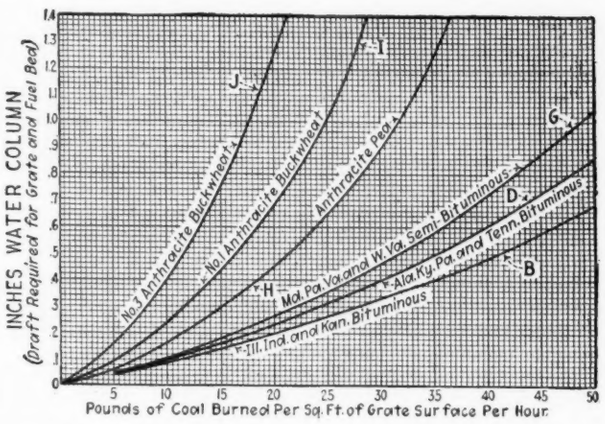

INCHES WATER COLUMN
(Draft Required for Grate and Fuel Bed)
Pounds of Coal Burned Per Sq. Ft. of Grate Surface Per Hour
No. 3 Anthracite Buckwheat
No. 1 Anthracite Buckwheat
Anthracite Pea
I-Ill. Ind. and Kan. Bituminous
H-Mo., Pa., Va. and W. Va. Semi-Bituminous
E-Ala., Ky., Pa. and Tenn. Bituminous

FIG. 12. DRAFTS REQUIRED FOR VARIOUS KINDS OF COAL AT DIFFERENT RATES OF COMBUSTION (FROM "STEAM")

able pressure increases from the top *T* of the stack down to *E*, where the effective pressure is 1 in. From *E* the available pressure decreases along *EA* to 0.00 in. at *A*.

In *AE* no propelling pressure is developed. Similarly, no draft pressure is developed in the horizontal portions of a flue-gas path. Practically no draft pressure is developed in a boiler setting because its vertical height is small as compared to that of a chimney. The pressure developed in *ET* pulls the water through *AE*. There is a pressure drop in *AE*, as shown, which is due to friction. The effective pressure (which is the available pressure at *E*) must be equal to the total available-pressure drop through *AE*; otherwise the pumps could not pull the water through *AE*. The sum of the available-draft pressure drops along the flue-gas path from the ashpit door to the smoke-conduit connection must equal the effective draft pressure.

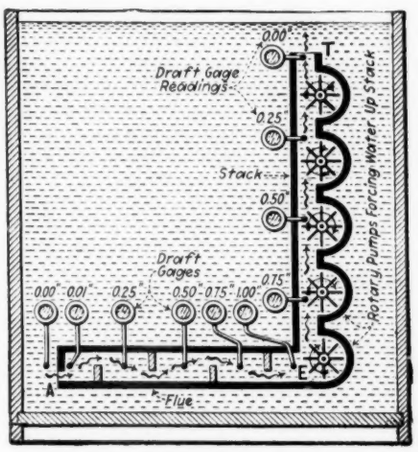


FIG. 13. PRINCIPLE OF DROP IN DRAFT PRESSURE

This law holds for any operating chimney. It means that any satisfactory chimney must be of sufficient height to develop a great enough draft pressure to circulate the flue gases through itself and in addition, it must provide enough excess draft pressure (effective draft pressure) at the smoke-conduit connection to pull the flue gases through the boilers and breechings. In order to determine the effective draft

pressure that a chimney for a given installation should develop, it is merely necessary to add together all the available-draft-pressure drops that occur in the boiler, setting and smoke conduit. The effective draft pressure must equal their sum.

To compute the chimney height required for a given installation, first determine the total draft pressure that is necessary, by using the following formula:

$$P''_D = 1.25\ (A.D.P.D._{BC}) = in.\ water\ column \qquad (3)$$

Wherein P''_D is the total draft pressure that the chimney must develop, from the smoke-conduit connection to its top, in inches water column, and $A.D.P.D._{BC}$ is the available-draft-pressure drop through the boiler and breeching up to the smoke-conduit connection, in inches water column.

Then, to ascertain the height that the chimney should have above the smoke connection to produce the total

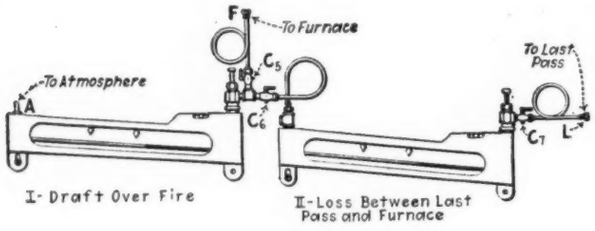


FIG. 14. PIPING OF DRAFT GAGES

draft pressure necessary, substitute the value for P''_D determined with formula 3 for P'_D in formula 1 and solve.

The flue area that a chimney should have should be based on the volume of gas that must be conducted from the boilers. Obviously, the pounds of coal burned per hour is an important consideration. Furthermore, the flue area of a chimney should be large enough so that the gases will be conducted in it without excessive pressure drop; otherwise, the effective draft pressure that the chimney develops will be insufficient.

A formula for computing chimney-flue area follows: This, as are practically all other chimney flue-area formulas, is based on practical experience rather than on mathematical analysis. A flue proportioned in accordance with it will convey the gases with about the 20 per cent drop, which is specified in Table II

$$A = \frac{W_c}{12\sqrt{L_h}} = area,\ sq.ft.$$

$$d = \sqrt{\frac{W_c}{9.43\sqrt{L_h}}} = diameter,\ ft.$$

Where

A = Cross-sectional flue area of chimney, in square feet.

L_h = Height of chimney above smoke-conduit-connection, in feet.

W_c = Coal burned per hour, in pounds;

d = Diameter of chimney flue, in square feet.

In using the formulas for square chimneys, the corners thereof should be neglected. The area taken is that of a circle that would just fit inside the chimney.

Draft-pressure gages used in practice differ from the elementary forms shown in Figs. 3, 7 and 9, which would not be sufficiently accurate. In the manometer-type "differential" gages, Fig. 14, ample accuracy is attained by inclining one leg of the gage-glass tube and using in it a light oil instead of water. Thereby, a small change in draft pressure will cause a considerable movement of the "meniscus" along the tube. The inclined scale may be so divided that differences of draft pressure of 0.01 in. water column may be read easily.

In the aneroid-type gages, Figs. 15 and 16, the pointer is actuated, through a lever system, by the movement of the elastic top of a metallic box. From the interior of the box a tube connects with the boiler space in which the draft pressure is to be measured. Aneroid gages may be either indicating or graphic.

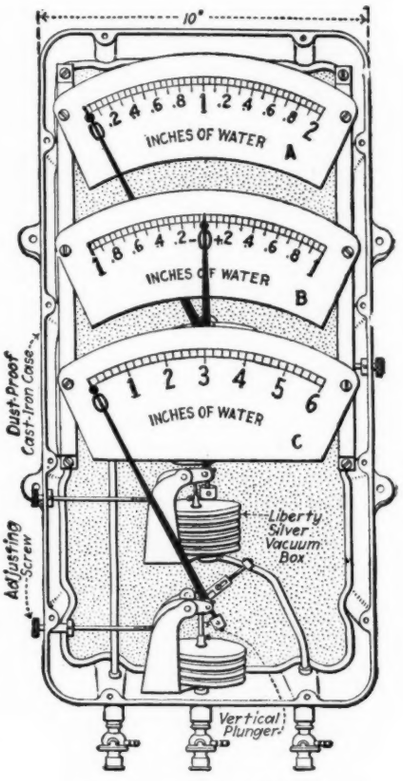


FIG. 15. "THREE IN ONE" DRAFT GAGE

Three-way cocks may be provided on draft-pressure gages whereby the gage may be connected either to the atmosphere or to the exploring tube.

In locating draft-pressure gages they always should be so placed that they can be seen by the fireman without effort. When so located, the fireman will learn to fire by the draft-pressure gage rather than by the steam gage. A good location is directly on the boiler front above and to one side of the

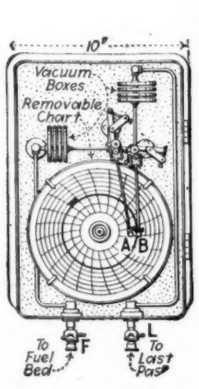


FIG. 16. GRAPHIC DRAFT GAGE

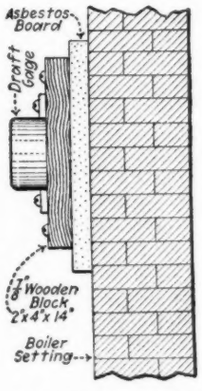


FIG. 17. GAGE MOUNTING BOARD

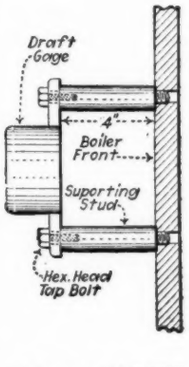


FIG. 18. ANOTHER GAGE MOUNTING

firedoor. In installing draft-pressure gages they may be mounted on the boiler front on a piece of well-seasoned wood, Fig. 17, which is backed by a slab of asbestos board. Or they may be supported, Fig. 18, on metal studs which permit a free circulation of air around the gage. Be certain that the gage is set level.

Draft-pressure gage piping may be ⅜- or ½-in. iron, except that close to the gage it is better to use brass pipe. If iron pipe is used near the gage, rust and scale may drop into the glass. Rubber tubing should not be used for permanent installations. The rubber soon dries out and cracks under the action of the heat. In installing draft-pressure gage exploring tubes, Fig. 19, a length of 1-in. iron pipe *T* is cemented into the setting. The tee on the outside end provides connection for the pipe to the gages. If it becomes clogged with soot, the plug can be removed and the obstruction prodded out. The location of exploring tubes in furnaces should be as near to the front of the furnace as is feasible and near the top of the chamber, so that slag will not accumulate in it. The best draft pressure to use in the furnace (U. S. Bureau of Mines Bulletin) is that which will satisfy the load conditions and produce the best percentage of CO_2 without CO and without fusing the ash. There is practically no exception to this rule. Determine the proper draft pressure for your plant by using a CO_2 gas analyzer. The best draft pressure over the fire for hand-fired furnaces burning bituminous coal ranges from 0.25 to 0.4 in. water column, but it may be materially more or less, depending on the grate used, the size and ash content of fuel and similar conditions.

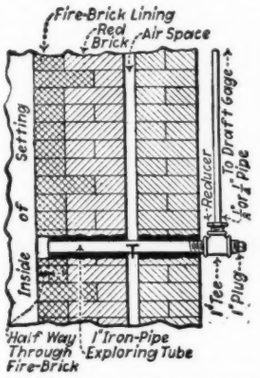


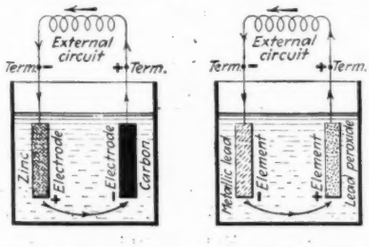
FIG. 19. DRAFT-GAGE EXPLORING TUBE IN SETTING

Features in Storage-Battery Operation

BY L. W. WEBB

There are two distinct kinds of storage batteries on the market: The lead storage battery or accumulator (acid type) and the Edison storage battery (alkaline type). The lead storage batteries are divided into two main types, the "Planté" or solid-plate type and the "Faure" or pasted type.

Each of these types possesses certain advantages and disadvantages as compared to the other. The Planté type is usually more expensive to make, gives less output per unit weight, is more easily injured by impurities and occupies more space for the same capacity. It has, however, a longer life, is less liable to injury by sediment in the bottom or shedding of the active material due to too rapid a charge or an overcharge, and will stand more frequent charging and discharging at varying rates.



Primary Battery Storage Battery

FIG. 1. SHOWING POLARITY AND CURRENT-FLOW IN PRIMARY AND STORAGE BATTERIES

In places where batteries are kept floating on the line at all times (as in power plants) except when called upon to furnish current at peak loads, the Planté type is the most satisfactory, while in places where weight is to be avoided as much as possible (as in motor cars, etc.) the pasted type is the most suitable. The capacity of the negative element in both types (the Planté especially) is less than that of the positive element, and in making up a unit cell one more negative than positive plate is used; this also allows both sides of each positive element to be active and tends to increase the battery capacity per unit weight. The pasted type, in addition to being lighter and costing less to manufacture, can produce much higher discharge rates without injury than the Planté type. In the pasted type the life of the negative element is usually twice that of the positive element. Each type has its own particular field and should be so used for best results. As a compromise between the two types, cells consisting of Planté-type positive elements and pasted-type negative elements are on the market, to be used where the good points of each are necessary, and it is claimed that in many cases these are superior to either. Their high-capacity negatives allow high rates of discharge, while their long-life positives give less trouble from shedding of the active material.

FIG. 2. ILLUSTRATING POLARITY IN A CLOSED CIRCUIT

Positive plates are of a dark-brown chocolate color owing to the coating of peroxide of lead; and negative plates are of a gray or slate-gray color, being lead "sponge" or finely divided metallic lead. Considered as a voltaic couple or primary battery, the terms "positive" and "negative" as applied to these plates are incorrect; for on discharge the current flows internally from the sponge-lead element to the lead-peroxide element, as it flows in the common battery from the zinc to the carbon element, because metallic lead is electropositive to lead peroxide and metallic zinc is electropositive to carbon. Thus, in the primary battery the positive terminal of the battery—that is, the terminal by which the current leaves the battery—is connected to the negative element, whereas the negative terminal, by which current enters the battery, is connected to the positive element. This has often caused confusion and misunderstanding; yet it is perfectly logical by the definition of polarity, for electricity must flow from positive to negative. When talking about the relative polarity of two terminals of a battery or a direct-current generator, it should be specified whether the external or internal circuit is being considered. Thus, let Fig. 2 represent a closed circuit or loop in which current is circulating; regarding one half of the circuit, *A* is positive with respect to *B;* regarding the other half, *A* is negative with respect to *B*. This, however, is a fine point which it has been considered wise to ignore in practical storage-battery work, where it might lead to dangerous errors; for example, in connecting the battery for parallel operation with a generator, the operator might connect the metallic-lead plate to the positive terminal of the generator, and the lead-peroxide plate to the negative terminal of the generator, resulting in a dead short-circuit on the machine through the battery and complete destruction of the latter.

The elements have therefore been designated by the polarity of the terminal they are connected to; that is, with respect to the external circuit.

Fig. 1 shows that current flows internally in the primary battery from the + to the — element and in the storage battery from — to +.

Method of Checking a Flywheel Design

By CLAN McGRALE

ACCURATE information for the designing of large wheels may be obtained in any good textbook, but is seldom in such shape as to enable an engineer who is contemplating increasing the speed of his engine to use the data to check the new speed conditions. For this reason the several factors necessary to consider in such instances are here taken up in sequence.

No unnecessary explanation will be given, assuming that anyone needing such condensed information on the subject will be able to use the developed formulas without difficulty. Although some of the short cuts and analyses are original, all the information was taken from standard works or built up on the practice of manufacturing concerns that had been making wheels for years. But in every case the methods were tested by application to the actual design of wheels before being included.

The Energy Stored in a Revolving Wheel

The kinetic energy of a flywheel may be found approximately by considering its mass to be concentrated at the mean radius of the rim. The mean radius

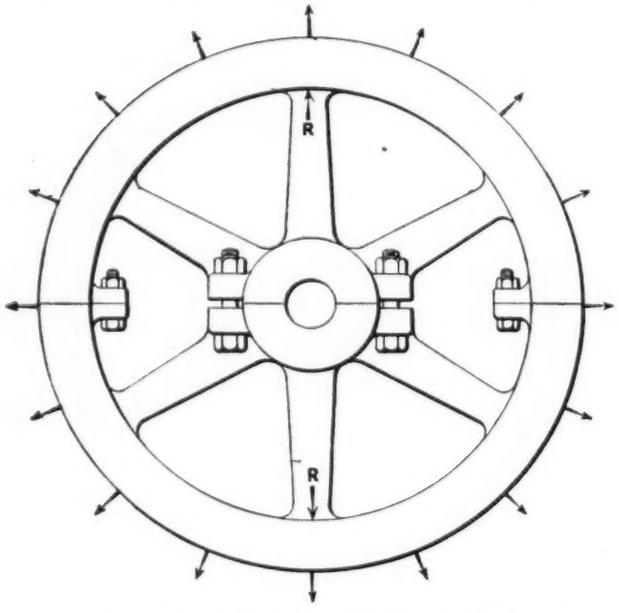


FIG. 1. CENTRIFUGAL STRESS IN WHEEL RIM

is generally taken as the distance from the center of the wheel to the center of gravity of the rim section.

Let v feet per second be the velocity of a point at the mean radius, and w the weight of the wheel. Then the kinetic energy is $K = \frac{wv^2}{2g}$.

Example: Suppose the mass of the rim of a flywheel is 10 tons and its mean radius is 6 ft. Find its kinetic energy at 90 r.p.m.

Velocity v at a point on the mean radius is $2\pi \times 6 \times \frac{90}{60} = 56.6$ ft. per sec.

Kinetic energy $= \frac{wv^2}{2g} = \frac{10 \times 56.6^2}{2 \times 32.2} = 495.6$ foot-tons.

Let N equal r.p.m., r equal mean radius in feet, w equal weight of wheel, and v equal velocity at a point on r in feet per second. Then

$$v = 2\pi r \times \frac{N}{60}; = \frac{\pi \times r \times N}{30} \text{ ft. per sec.}$$

$$\text{Kinetic energy} = K = \frac{wv^2}{2g}; = \frac{w}{2g} \times \left(\frac{N \times \pi \times r}{30}\right)^2;$$

$$= \left(\frac{\pi^2 \times w \times r^2}{1800\, g}\right) \times N^2$$

The coefficient of N^2 in this result is constant for a given wheel, so it can be stated that the kinetic energy of a given wheel depends simply upon the square of the r.p.m. If, therefore, the kinetic energy of a wheel at any given speed, say 1 r.p.m., is known, its energy at any other speed can be calculated by simple proportion.

Let K equal kinetic energy at 1 r.p.m. and k equal kinetic energy at N r.p.m. Then

$$K : k :: 1^2 : N^2 \text{ or } k = KN^2$$

Fluctuation of Speed in the Wheel

The fluctuation of speed in a flywheel can now be calculated if the fluctuation in the demand for energy is known. Assume a wheel with a weight of w pounds, with a mean radius of r feet. If the velocity of a point at the mean radius is v feet per second at a given instant, where v is equal to $2\pi rN$, N being the revolutions per second; then

$$\text{Kinetic energy} = K = \frac{wv^2}{2g} \text{ ft.-lb.}$$

Suppose, now, that there is a demand for E foot-pounds of energy which has to be supplied from the store of energy in the wheel. The wheel will slow down while supplying this. Call v_1 the velocity of a point on the mean radius when the change in speed is complete. Then the kinetic energy at the new speed is $K_1 = \frac{wv_1^2}{2g}$ ft.-lb.

The wheel loses kinetic energy amounting to K minus K_1, and this has been transformed into E foot-pounds of mechanical work. Therefore

$$E = K - K_1 = \left(\frac{wv^2}{2g}\right) - \left(\frac{wv_1^2}{2g}\right) = \frac{w}{2g}(v^2 - v_1^2)$$

$$E \times \frac{2g}{w} = v^2 - v_1^2$$

Example: A wheel of 2,000 lb. mass at a mean radius of 3 ft. has a speed of 180 r.p.m. Suppose 4,000 ft.-lb. of work to be taken out of it, and calculate its new speed.

Velocity is $v = \frac{180}{60} \times 2\pi r; = 3 \times 2 \times \pi \times 3 = 56.55$ ft. per sec.

$v^2 = 56.55^2 = 3{,}198.$

$v^2 - v_1^2 = \frac{2g}{w} \times W$; substituting, $3{,}198 - v_1^2 = \frac{64.4}{2{,}000} \times 4{,}000.$

$v_1^2 = 3{,}198 - 128.8 = 3{,}069.2$ or $v_1 = \sqrt{3{,}069.2}$; $= 55.4$ ft. per sec.

Then the new speed N will be equal to

$$\frac{55.4 \times 60}{2\pi r}; = \frac{55.4 \times 60}{2 \times \pi \times 3}; = 176.3 \text{ } r.p.m.$$

Bursting Effect of Centrifugal Force

Every piece of material in the rim will produce a centrifugal force directed from the center outward, Fig. 1. Let w equal weight of rim, in pounds per foot of circumference, v equal velocity of rim in feet per

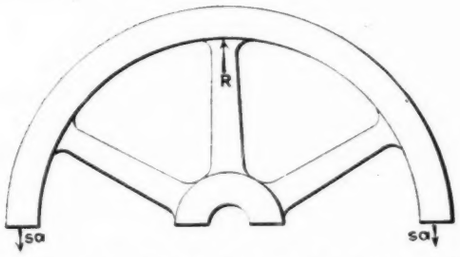


FIG. 2. RESULTANT STRESS AT RIM JOINT

second, and r equal mean radius of rim in feet. Then the centrifugal force per foot of circumference will be: $\frac{wv^2}{gr}$ pounds.

The resultant centrifugal force for half the wheel will be $\frac{2}{\pi}$ times the sum of all the unit centrifugal forces acting on one-half the wheel rim, or

$$R = \frac{wv^2}{gr} \times \frac{2}{\pi} = \frac{2wv^2}{g} \text{ } lb.$$

To find the effect of this resultant of the centrifugal forces upon the rim joint, let a equal area of rim section in square inches and s equal tensile stress on a in pounds per square inch. Then

$R = 2sa$. Fig. 2. or $\frac{2wv^2}{g} = 2sa$. $s = \frac{wv^2}{ga}$ *lb. per sq.in.* also, w is the weight of material per cubic foot $\times 1 \times \frac{a}{144}$. This quantity is equivalent to a strip of metal on the circumference, of one square inch cross-section, and one foot long. Substituting the value of w, the equation becomes

$$s = \frac{\textit{weight per cubic foot} \times v^2}{144 \times g} \text{ } \textit{lb. per sq.in.}$$

This equation shows that the tensile stress due to centrifugal force is independent of the sectional area of the rim.

Example: Required the stress due to centrifugal force in the rim of a cast-iron wheel 24 ft. in diameter, 56 in. face, rim 1½ in. thick, at 70 r.p.m., assuming cast iron to weigh 450 lb. per cubic foot.

$$v = \frac{70 \times \pi \, 24}{60} = 88 \textit{ ft. per sec. on the rim}$$

$$s = \frac{wv^2}{144g}; = \frac{450 \times v^2}{144 \times g}; = \frac{v^2}{10}, \textit{ nearly}; = \frac{88 \times 88}{10};$$

$$= 772.5 \textit{ lb. per sq. in.}$$

The number of revolutions per minute of the wheel necessary to produce a pressure that will burst the wheel can now be found by simple proportion.

Let S equal stress per square inch at N r.p.m., N equal r.p.m., s equal ultimate strength of the material, and x equal r.p.m. at the time of bursting. Then

$$S : s :: N^2 : x^2 \quad \text{or, } x^2 = \frac{s \times N^2}{S}.$$

A tensile strength of 10,000 lb. per sq.in. is as much as can be assumed for cast iron with safety. Using a factor of safety of 10 gives a maximum allowable strain of 1,000 lb. per sq.in.

Calculations for Joint Stress

In calculating the strength of the rim joint, let F equal the force tending to rupture the rim, which may be either the centrifugal force ($R = 2sa$, Fig. 2), or pull of belts or ropes, A equal combined sectional area of all rim bolts, S equal allowable unit stress in bolts, x equal distance from inner edge of bolt flange to center line of bolts, and y equal distance from inner edge of bolt flange to center of gravity of rim section.

If the bolts could be placed at the point of application of the force F, their combined effective section A would be $\frac{F}{S}$.

In actual design the center line of the bolts must be placed at some distance from the point of application of the force F, in which case the bolts are subjected to an additional strain due to the bending moment at the rim joint. If this bending moment is taken up by the flexure of the rim, the bolt section will be $\frac{F}{S}$ as before. But if the rim and bolt flanges are rigid enough to resist any deformation, the total strain will come upon the bolts.

Under this condition the net combined cross-section A of the bolts must be found by multiplying $\frac{F}{S}$ by

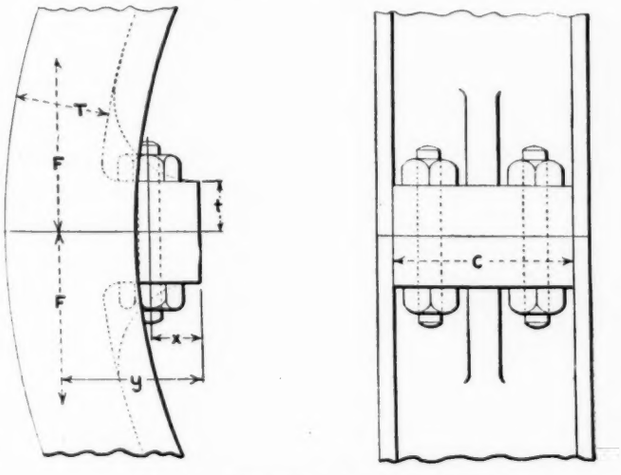


FIG. 3. FORCES ON RIM BOLTS

the ratio of the leverage y of the force F to the leverage x of the resistance of the bolts, Fig. 3. Hence, if it is assumed that $x = \frac{y}{2}$, a very common value, the combined cross-sectional area of the bolts is $A = 2\frac{F}{S}$.

By using studs instead of through bolts, the center line of the bolts can be placed nearer the rim, in which case, for the same depth of flange, the ratio $\frac{y}{x}$ may be made less than 2.

In order to obtain ample strength at the rim, the combined cross-sectional area of the bolts should be determined upon the supposition that the full bending moment will be thrown on the bolts. Then the bolt flanges or lugs must be heavy enough to resist any bending due to the force F. The bolt flanges will be as strong as the rim if the respective moments of resistance are made equal to each other.

So, if B equal the face of the wheel, b equal the breadth of the bolt flange c less the total widths of bolt holes, T equal the mean thickness of the rim, t equal the thickness of the bolt flange or lug, and S equal the allowable unit stress in the metal, then

$$BTS \times y = btS \times \frac{t}{2}.$$

This thickness may be reduced somewhat if strengthening ribs are carried from the rim to the lower edge of the bolt flange.

If the rim is properly bolted, the principal strains to which the hub bolts are subjected are those due to the weight of the hub and arms, and the tension produced by keying to the shaft. In practice some designers make the hub joint so that the combined cross-section of all the hub bolts is equal to one-half the combined cross-section of all the rim bolts. However, this is not the usual practice. It is safer to make the combined cross-sectional area of the hub bolts equal to the combined cross-sectional area of the rim bolts.

The best practice calls for arms of elliptical section, with the short dimension equal to 0.4 of the long dimension. Unwin's formula for arms is, for single belt pulleys, $d = 0.6337\sqrt[3]{\frac{BD}{n}}$; and for double belt pulleys $d = 0.798\sqrt[3]{\frac{BD}{n}}$. In these d is the depth of the arm, or the long dimension, B the width of the belt, D the diameter of the pulley, and n the number of arms.

The following formulas have been found to be more practical, and were developed from the practice and experience of a concern which has been manufacturing pulleys, rope sheaves, and flywheels for over fifty years. Let

D = Diameter of rope in inches.
R = Radius of pulley or sheave in inches. In pulleys this is the radius of the rim; in rope sheaves it is the radius to the center line of the rope in the groove.
N = Number of ropes.
W = Width of belt in inches.
H = Horsepower of a belt 1 in. in width as given in a standard table.
n = Number of arms.
a = Short dimension of arm.
b = Long dimension of arm.

For rope sheaves

$$a = \sqrt[3]{.265\frac{D^2 \times R \times N}{n}}.$$

For pulleys

$$a = \sqrt[3]{.0083\frac{H \times W \times R}{n}}$$

Apply the result at the hub. Make the arms of elliptical section, with $a = 0.4b$, or $b = 2.5a$.

The taper of the arm from hub to rim is $\frac{1}{8}$ in. per foot, $\frac{1}{16}$ in. on each side, but in no case is the depth of the arm at the rim to be less than $\frac{1}{3}$ of the depth at the hub.

For wheels up to 19 in. face they use one set of arms; 19 in. to 50 in., two sets; and above 50-in. face, three sets.

The best practice is to use 10,000 lb. in tension and 18,000 lb. in flexure, for maximum unit stresses for cast iron, with a factor of safety of 10.

The same concern makes the length of the hubs on solid pulleys equal to $\frac{3}{4}$ of the face; and on split pulleys the length is $\frac{3}{4}$ of the face.

With the Diesel Engine in India

By P. P. Talaty

Our 1,000-hp. Diesel was overhauled some time ago and, as is usual, all parts were thoroughly cleaned, the bearings adjusted and everything placed in good running condition. But on starting, to our surprise, a knock appeared in one cylinder, making itself evident at each power stroke. The plant force discussed the trouble, it being the practice to allow, even invite, an expression from every man in the plant when anything unusual occurred. The watch engineers agreed that the knock was a piston "slap" resulting from the large clearance between the piston and liner at the upper dead center, this clearance being 0.124 in. Since the clearance had existed for some time, there was no basis for this contention. The idea was then advanced that the slackness of the piston pin in the boss at A, Fig. 1, was the cause, as a feeler gage showed 0.012-in. clearance between the pin and boss alongside the key. It was assumed that this slackness allowed the piston to tip to one side as the crank passed the upper dead center. Of course a pound would result. This sounded very reasonable, and the piston pin was removed and turned true on a lathe. New babbitt-filled brasses were then fitted to the pin, with a running clearance of 0.005 in. The crankpin-bearing brasses were also taken up, giving a clearance of 0.005 in., and a side clearance between the crank webs and brass of 0.010 to 0.012 in., as usual. All this work was productive of no good, for the pound was as stubborn as ever. Very much disan-

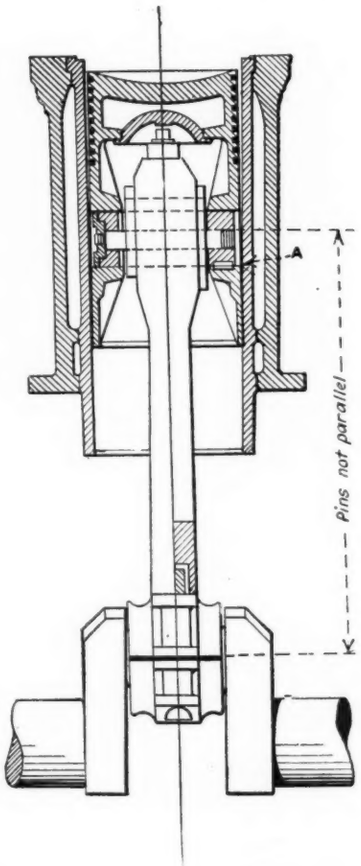


FIG. 1. PISTON PIN SLACK AND OUT OF ALIGNMENT WITH CRANKPIN

pointed, we removed the crank brasses and to our surprise found that the crankpin bearing was 0.007 in. out of being square with the crankpin, the bore of the bearing being out of parallel with the bearing top. This may have been due to wear or defect in the original brasses. It is very apparent that the connecting rod under this condition would not swing true with the crankpin, and of course would pound as the rod was forced to one side as the crank rotated. Upon securing a new brass, we found the same misalignment, as shown in Fig. 2, existed. We then rebabbitted the bearing and bored it exactly parallel with the top face. Special pains were taken with the fitting of the bearing to the pin, a side clearance of 0.01 in. being allowed on both sides. We congratulated ourselves that we had overcome the "jinx" that had troubled us.

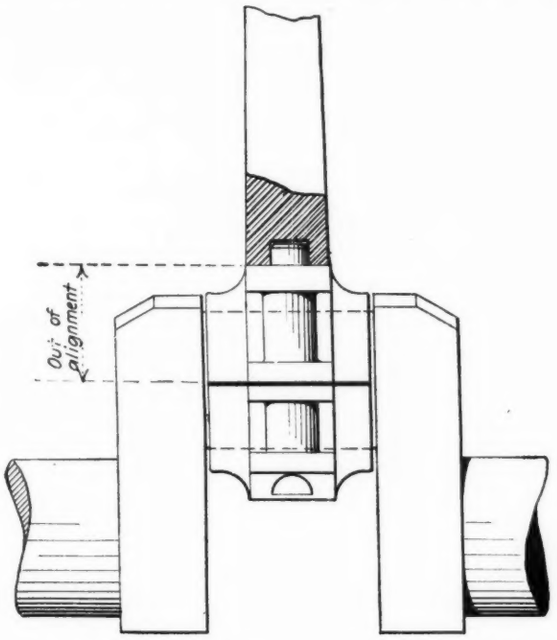


FIG. 2. CRANKPIN BEARING OUT OF ALIGNMENT WITH TOP FACE

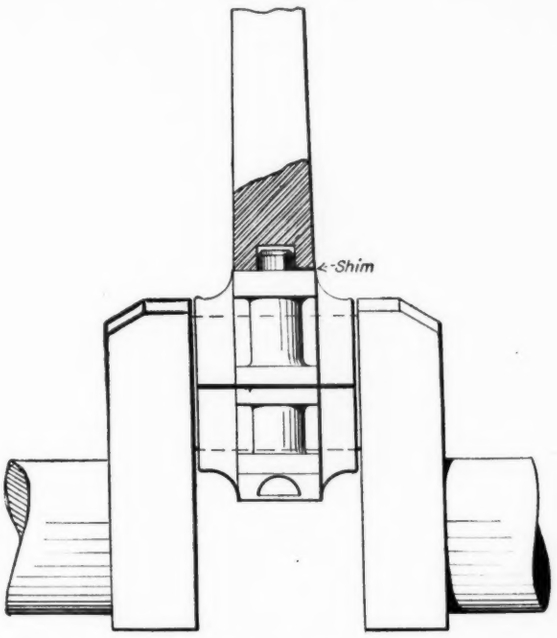


FIG. 3. SHOWING HOW MISALIGNMENT OF SHIMS WAS CORRECTED

But, no, the troubled spirits were still alive, for the knock was there just the same after the engine was started. The flywheel and crankshaft had a decided sidewise or shifting motion which, if allowed to continue, would speedily "bell" the crankpin bearings and ruin the cylinder liner. So we immediately decided to build up the bearing thrust rings to reduce this side play. This was done by building up the ring with babbitt, turning it off true and smooth.

Although the side play was reduced, the pound still persisted. We felt quite discouraged, but renewed our efforts to discover the cause of the trouble. We finally decided that the connecting rod and piston pin were not square with the crankshaft, being somewhat in the condition shown in Fig. 1. To offset this supposed misalignment, a tin shim was inserted on one side of the rod boss as illustrated in Fig. 3. To our surprise and delight the knock did not show up again and the engine carried the load as nicely as ever.

The bearings on the other cranks now began to knock. Why this was I do not undertake to explain. A small shim inserted around the boss on each bearing eliminated this knock. To avoid all danger of this trouble, we secured a new piston and pin as well as new piston pin and crankpin bearings. The use of these new pins failed to prevent a recurrence of knocking, and it was my opinion that entirely too little side clearance (0.010 in.) between the crankpin bearing and webs was used. The clearance should be increased to two or three times this amount. With this amount of clearance the knock has disappeared even though no shim is used at the boss. I believe that the piston, being slack in the cylinder liner, tends to tilt, and as a result the crankpin pressure is on one side of the upper half of the bearing. If the clearance is small, this tilting of the piston causes the brass to bind against the crank web. With ample clearance no binding can occur and no pound is heard.

The Care and Maintenance of Electrical Equipment

BY E. S. BAXTER

After the electrical equipment of a plant has been installed, it becomes the duty of someone to care for it and keep it running efficiently. The rules of installation of electrical equipment are fairly well known, and a recourse to the electrical codes will usually set one right when in doubt. However, carelessness in installation is very often the cause of much trouble and annoyance until it is rectified, and when a motor is just installed, it should be tested for mechanical defects, such as poor alignment, loose bolts, etc., before being connected to the lines. Also, care should be taken to see that the motor has been correctly leveled, that there are no nails, screws or tools lying in or around it, which would be likely to cause serious trouble.

After a motor has been correctly set up, properly wired and well lubricated, a close watch should be kept during its trial run for heating and any other symptoms of trouble. The load, speed, etc., should be watched, to see that the motor is suited to the load it is driving, and a record kept of the readings. The load should be neither too high, for this will cause heat-

ing and possibly burn-outs, nor too low, for this causes low power factor and efficiency. Should the motor prove to be suited to its load, it should be so recorded.

This is only the beginning of the work, however. It happens too often that after equipment is installed, no attention is paid to it until trouble is reported, when it is too late. Regular inspection should immediately follow the installation at intervals depending on the conditions under which it is operating; such conditions should determine the periods of oiling, oil renewal and overhauling. Regular inspections should also include the testing of the air gap of the motor and inspection of the rotor or stator winding to locate any loose conductors or connections. An ordinary hacksaw blade, ground to size with the teeth ground down and a handle on one end, makes a handy air-gap tester. When it is passed around in the air gap between stator and rotor, the condition of the air gap can be determined even though it may be difficult to look through it; it will also show any appreciable wear in the bearings.

Heating of Electric Motors

Heating in motors can generally be located, and it is usually easy to determine whether the heating is due to mechanical or electrical trouble. If the motors have been in service a long time, heating may indicate: First, that the shafting is out of line or the load has become abnormal for some other reason (however, a load test will soon determine whether the motor is overloaded); secondly, that there is dust or other foreign matter settled between the coils in the windings, in which case the ventilation will be poor (a good cleaning will remove the trouble if this be the cause); thirdly, a short or partial short-circuit will develop heating. This, however, is usually localized and can be traced with the fingers, as the coil that is short-circuited will be hotter than the rest. Care should always be taken that the motor is assembled perfectly and that no grit or dirt has been allowed to accumulate on the shaft or in the bearing housings.

Value of Regular Inspections

It can readily be seen that regular inspections will give to the man in charge a good knowledge of his equipment and the conditions to be met; after one or two inspection trips, he will probably be able to determine for himself how often these trips should be made. One lesson to be learned is that the equipment to be installed must be capable of withstanding the conditions to be met, for the conditions cannot be made to fit the equipment.

Frequent inspections require suitable testing apparatus. This will pay for itself in a surprisingly short time. For example, in one instance where the purchase of some new equipment was contemplated, the testing equipment on hand consisted only of a polyphase indicating wattmeter. But it seemed probable that this did not give reliable readings on account of the rapidly fluctuating load. A recording polyphase wattmeter was therefore procured, and it was found that the readings obtained with the indicating meter had been too low. If equipment had been purchased on this basis, it would undoubtedly have proved inadequate, and would have caused considerable trouble and expense. The recording meter probably paid for itself in one test.

When the load any motor operates is changed, the motor should immediately be put under test and the result recorded on its record card; if the new load is greater or considerably below the capacity of the motor, another machine should be substituted. An electrician in charge of a plant, without adequate instruments to enable him to determine the exact conditions of operation, is badly handicapped and is not responsible if his costs are high. Too many employers expect a man to rely on rule-of-thumb methods and are prone to avoid any expenditure as long as everything keeps on moving.

In many cases the writer considers that operating conditions in a plant would be bettered and repair costs materially cut if the man in charge would don a suit of overalls once in a while and take part in the inspection and oiling rounds. It makes for a better understanding both of men and equipment and creates a closer bond in the operating force.

Repair Costs in Specific Plant

The table gives the rewinding costs for three years in a plant now equipped with 315 motors, ranging from ½-hp. single-phase to 50-hp. three-phase.

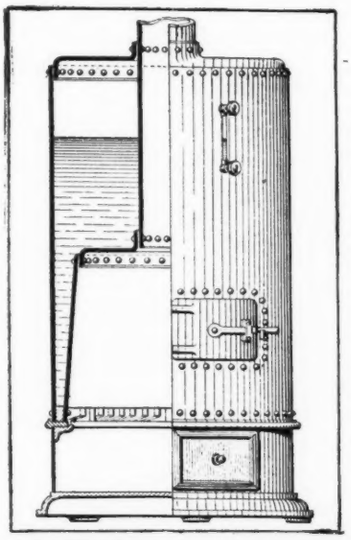
AVERAGE COST OF REPAIRS PER MOTOR PER YEAR, FOR 1918, 1919 AND 1920

1918—Number of motors in service		289
	Total cost of motor repairs	$102.36
	Average repair cost per motor per year	$0.354
1919—Number of motors in service		305
	Total cost of motor repairs	$102.92
	Average repair cost per motor per year	$0.337
1920—Number of motors in service		313
	Total cost of motor repairs	$121.27
	Average repair cost per motor per year	$0.387

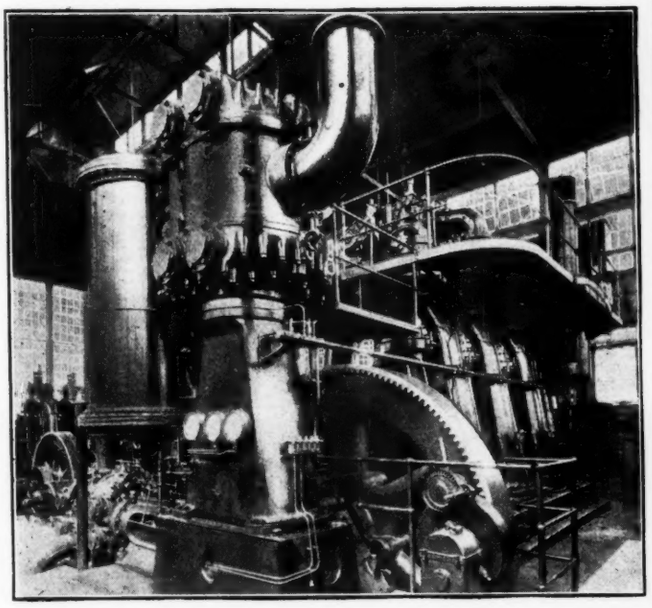
All the motors 10 hp. or larger are controlled by auto-starters and equipped with circuit breakers with overload release in the running side. The motors from 2 to 7.5 hp. are equipped with overload-release circuit breakers set for 10 per cent overload. All the small single-phase motors are equipped with small oil switches of a special snap-switch type. All the auto-starters are inspected every six months and a record kept, according to the serial number of the equipment, of the number of contacts renewed, the condition of the oil in the tank, etc. The circuit breakers on the smaller sizes, where they serve as switches, are inspected every three months, as are all the small oil switches. In this way the condition of the various equipment is always known. Some of the motors have been running for more than ten years and never had a bearing changed or a shutdown caused by any defect in the installation or maintenance and, except for an occasional cleaning, have never left the bedplate. It is a fast rule that every motor removed for repairs or cleaning must be tested and in good condition before it is again placed in line for service. It is also given a coat of good insulating varnish, and in this way the equipment is practically as good as new.

In summing up, the secret of success in maintenance is looking after equipment and learning the exact condition under which it is operating.

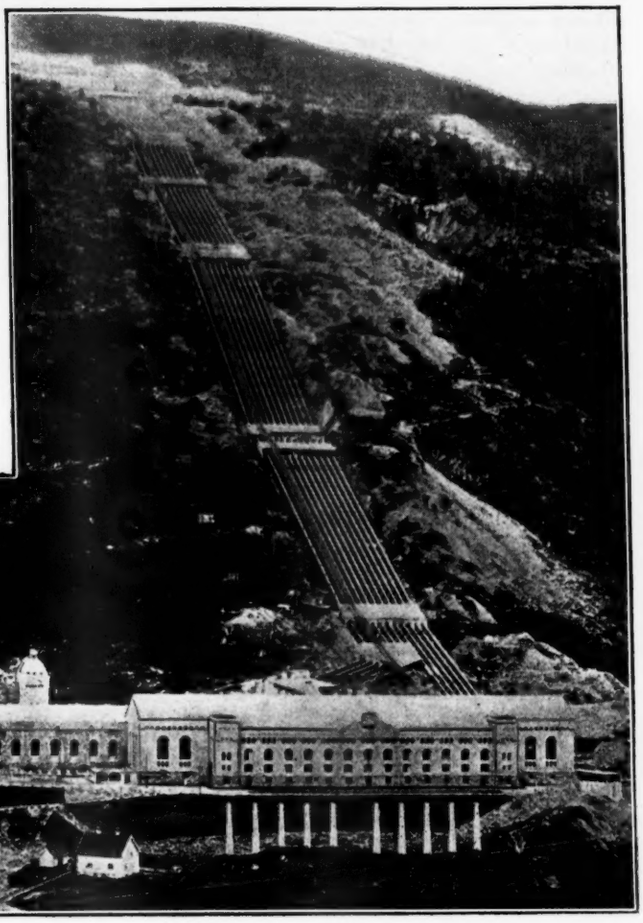
An engineer in an English rolling mill, according to *The Engineer*, has an interesting theory as to the best method of bedding down a big engine. He claims that it is better not to tighten the holding-down bolts too hard at first, but to leave a very little slackness; then, when the engine is running, it will work on the sub-base, and the ridges left on the two castings by the planer tool will grind into each other, thus forming an effective lock. The bolts should then be tightened down, after which the two castings may almost be considered as one.



An old boiler that died hard—The photograph at the right was taken through a hole cut out after the explosion, while the sketch shows the general design of the boiler. Note that the crown sheet gave way at the heel of the flange and was lapped over the flue opening, thus shutting off relief in this direction and sending the steam downward. This made a perfect skyrocket of the old boiler, so that it cut a clean hole in the roof and came down about 100 ft. away.



A vertical-horizontal compound air compressor, driven by a 750-hp. Nordberg Diesel engine, supplying air to converted steam hammers. The speed automatically varies from 180 to 80 r.p.m. to meet varying demands for air. The capacity is 4,000 cu.ft. of free air per minute, and the pressure is about 100 lb. gage. The unit is installed at the Oklahoma Iron Works, Tulsa, Oklahoma.



Below—A hydro plant in the mountains of Norway, where water is the chief source of power. *Photo by Galloway.*

Efficiencies of Internal-Combustion Engines

The present-day popularity of the Diesel oil engine, with its extremely high efficiency in converting the heat in the fuel into work, has caused many to assume that the Diesel efficiency surpasses that of any other internal-combustion engine cycle.

In Fig. 1 appears an indicator card *ABCD*. This is the kind of diagram made by the indicator when

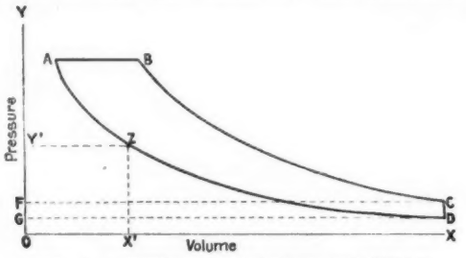


FIG. 1. DIESEL-INDICATOR DIAGRAM

connected to a Diesel engine. In this diagram the line *DA* represents the change in volume and pressure within the cylinder as the piston compresses the air charge; that is, the distance *X'Z* that the point *Z* is from the base line *OX* represents to some scale the pressure within the cylinder when the piston is at a distance represented by *Y'Z* from the zero volume line *OY*. At *A* the fuel valve opens and fuel is injected into the cylinder as the piston moves on the out, or power, stroke. The rate of injection in the ideal engine is such that the line *AB* is horizontal; that is, the heat of the fuel is added at constant pressure. At *B* the fuel injection ceases and the gases expand along the *BC*. At *C* the exhaust valve opens, allowing the gases to blow out as the pressure falls from *C* to *D*. The

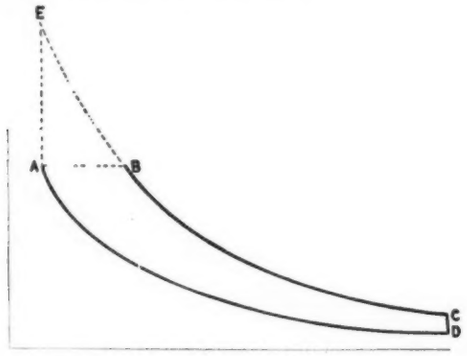


FIG. 2. COMPARISON OF OTTO AND DIESEL CYCLES

work done by the engine is proportional to the area of the diagram *ABCD;* this work will be called *W*. The gases blowing out through the exhaust valve carry the heat which has not performed any work and this is lost. The lost heat or energy is proportional by some scale to the area *CDGF* and will be termed *E*. Now, of the heat in the fuel, which will be called *H*, part has done the work *W* and part was lost through the exhaust, this latter being *E*. Then the heat added $H = E + W$. Since the efficiency of the engine is the ratio of the heat turned into work to the heat added, the efficiency $\frac{W}{H} = \frac{W}{E+W}$ or $\frac{E+W-E}{E+W}$. The efficiency is, then, $1 - \frac{E}{E+W}$. This means that if it were possible to have an engine in which the work done was more than with the Diesel, while the heat lost was the same, the second engine would be more efficient, as the fraction $\frac{E}{E+W}$ would decrease as *W* increases.

Taking the Diesel diagram in Fig. 1. At *B* all the energy that the fuel contains has been introduced. Suppose, in Fig. 2, we extend the adiabatic expansion curve *CB* until it meets a vertical line through *A* at the point *E*. The diagram thus made, *AECD*, is that of an explosive, or Otto cycle, engine with a compression at *A* the same as the Diesel. The line *AE* would be that caused by the explosion of a fuel charge, which in expanding would follow the curve *EC* from *E* through *B* to *C*. The heat *E* lost with this diagram is evidently the same as with the Diesel, and is proportional to the area *CDGF*. The work done is proportional to the diagram area *AECDA*. This work is greater than that of the Diesel engine by the area *AEB*. It follows that with the same compression as

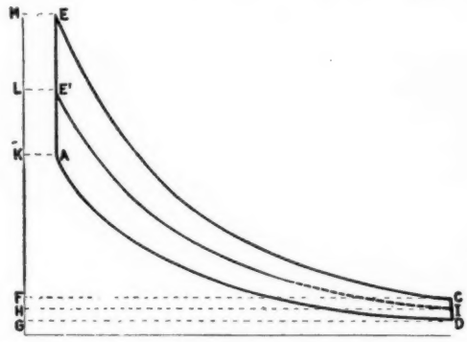


FIG. 3. OTTO-CYCLE ENGINE WITH VARYING FUEL CHARGE

the Diesel the Otto-cycle engine would be more efficient than the Diesel.

The question naturally arises: If the fuel charge in the Otto engine is such that the pressure does not rise to *E*, but stops at a lower point *E'*, as in Fig. 3, will the efficiency still be higher than that of a Diesel with the same compression as at *A?*

In Fig. 3 the energy added by the combustion from *A* to *E* is proportional to the area *AKME*, and the energy added by the combustion of the second engine from *A* to *E'* is proportional to the area *AKLE'*. The heat lost in the exhaust from *C* to *D* in the first engine is proportional to the area *CFGD*, and the energy lost by the second engine is proportional to the area *IHGD*. Since the ratio of *ID* to *DC* is the same as the ratio of *AE'* to *AE*, for the ratio of the pressures of the two expansion curves at any volume is constant, the ratio of the heat lost by the two engines is proportional to the ratio of the heat added in the engine. The efficiencies are then the same; for example, if $AE' = \frac{1}{2}AE$ and $ID = \frac{1}{2}CD$, then the efficiency of first engine is $\frac{H-E}{H}$ and of the second engine the efficiency is $\frac{\frac{1}{2}H - \frac{1}{2}E}{\frac{1}{2}H}$, or $\frac{H-E}{H}$, as before. For the same compression pressures the explosive, or Otto-cycle, engine is more efficient than the Diesel. Practical considerations present the Otto-cycle compressions being as high as the Diesel since the pressure at *B* would be too high for safety, but even with 250 lb. compression the Otto-cycle engine practically equals the Diesel efficiency.

EDITORIALS

Why Not a Users' Coal Pool?

AN EXCELLENT suggestion regarding the possibilities of co-operative buying and reserve storage of coal has been made by Dr. David L. Wing. The proposal is that coal users, particularly industrial interests and local utility companies, should combine to arrange for the purchase, storage and supply of the reserves of coal which are essential in most parts of the country in order to insure uninterrupted supply of the proper quality of fuel.

Large, well-managed operations usually are much more efficient than the same amount of business done by a considerable number of small units. In the handling of coal this is particularly true. A well-organized purchasing and distributing agency which would be responsible for the stocking of necessary reserves, could buy efficiently, handle the coal economically and store it under proper conditions to minimize cost and losses. It is no easy task to draft a proper coal contract, to see that it is lived up to throughout the year, to unload, store and reclaim several thousand tons of coal. Naturally, each industrial establishment has all these problems confronting it if it works alone. Perhaps there are only a thousand or maybe five thousand tons of coal to be handled in the course of the year, and yet skill on all phases of the work is just as important as if five hundred thousand tons were to be managed for a hundred establishments. Naturally, the cost of the brains to do this work is almost negligible if distributed over several hundred thousands of tons, but if the skill must be paid for in connection with only a few carloads, the cost becomes prohibitive. Similarly, the investment for storage facilities on a large scale will be small per ton of storage capacity; for small establishments many time this investment would be necessary. The handling charges out of the cars on to the stockpile and reclaiming from the stockpile are correspondingly cheap or expensive for large or small plants respectively.

The coal producer who is most directly interested in regularity of business will also profit by dealing with such large units. If he knows that specialists are to handle his product at the receiving end, not only will he be more careful in his preparation of the fuel and shipment of it, but also he can rest assured that a business-like and fair transaction is insured throughout the entire period of his contracts. Thus favorable contract conditions which are fair to all parties and yet enforceable can be expected.

The pooling of a large part of the industrial fuel supply of a community would not mean the dumping of all kinds of coal indiscriminately into a single pile and causing each one to take just the same kind of fuel that everyone else receives. Such a proposal would be absurd and the scheme wholly unworkable. However, the requirements of different fuel users is by no means a serious complication. Half a dozen or even a score of coal pools could be operated together by a single agency and very efficient results insured. Thus each user could almost certainly get at all times just the kind of coal he preferred or would know that other reserves were available to him so that, lacking coal suited to his needs, he would not have to do altogether without fuel.

It will be well for the engineers of power plants in many localities carefully to consider Dr. Wing's proposals and see if there are not opportunities for large economy in their particular localities. If the scheme works for export coal, and it seems to be a success in that field, domestic users certainly want to take advantage of the idea.

Where Greatest Attention Is Required

BOILERS differ in their operation from other power-plant equipment in that it is possible to operate all types of good design up to practically the same efficiency, irrespective of their size. With other power-plant equipment, with the possible exception of oil engines, the efficiency is fixed to a large degree by the size of the apparatus. In standard electric generators and motors the efficiency for small sizes ranges down to around sixty to seventy per cent, whereas in the larger sizes efficiencies as high as ninety-eight per cent have been obtained. With large steam turbines operating on high-pressure high-temperature steam expanding down to low vacuum, their best water rate is down to between ten and eleven pounds per kilowatt-hour; with small units the water rate may be nearly double this. With reciprocating engines similar wide ranges in steam consumption are found, also considerable difference of efficiency in engines of the same size but of different types.

With boilers it is possible to obtain around eighty per cent efficiency with almost any type burning a fairly good grade of coal. There is, however, no other part of the station equipment in which there are so many factors under human control that influence the efficiency as with the boiler. When an electric generator has been properly designed and installed, its efficiency is practically fixed irrespective of what the attendants may do. If the machine is neglected, its service may be impaired. but its efficiency will remain the same under given load conditions. This is true of the turbine and steam engine, although not to the degree that it is for the electric generators. However, when the former are properly installed and put in condition to operate at their best water rates for given loads, they will continue to operate at these efficiencies for considerable periods, when expanding through a given range of pressure and temperature. Although conditions of the turbine blading, and valves and valve gears of reciprocating engines will influence efficiency, this in general becomes a serious factor only after considerable periods of service. But the efficiency of boilers is influenced by a number of factors immediately under the control of the operator —the amount of air, methods of firing, condition of boiler surfaces, both inside and out, temperature of feed

water, etc.—all of which, if not given the continuous attention of the operator, may cause serious loss of efficiency. In addition the arrangement of baffling, proper heat insulation, not only of the exposed surface of the boiler but also of the settings, and the prevention of air leaks into the furnace may have a marked influence on efficiency. As a result, instead of boilers operating at an efficiency of around eighty, many are found operating at fifty or less.

Although much has been done during recent years in the development of apparatus to eliminate the human element in boiler operation, this part of the plant remains the one requiring the greatest attention. Furthermore, the evidence indicates that it is going to continue to require the greatest interest, and strange as it may seem, it is only at this late date that there is a realization that graduation of power-plant operators should be from the engine room to the boiler room, rather than from the boiler room to the engine room.

What Are the Essentials of a Contract?

IT IS an old saying that "he who is his own lawyer has a fool for a client." Similar remarks of a derogatory nature might be made about the business man who would attempt, without technical advice, to pass judgment on the details of design and operation of a modern power plant. Nevertheless it would do the business man no harm to gain a general idea of the meaning, for example, of the kilowatt-hour for which he must spend his good money. Likewise it will not hurt any engineer and may help him greatly to know the fundamental requirements which every contract must meet if it is to be legally enforceable.

The following is a complete definition of a contract: "A contract is an agreement entered into between two or more competent parties for a valuable consideration to do or not to do something that is lawful."

Putting them in tabular form, the essentials are as follows:

1. "*Agreement*"—All parties to the contract must agree on the same thing. There must be no misunderstanding about the point at issue.
2. "*Two or more competent parties*"—The parties must be competent in the eyes of the law to enter into the contract.
3. "*Valuable consideration*"—The arrangement must be such that each party will receive something having value (however small) in the eyes of the law, in return for what he gives. A promise to give a present freely, with nothing in return, cannot be enforced at law.
4. "*To do or not to do something that is lawful*"—An agreement requiring the commission of an illegal act is not an enforceable contract.

An arrangement that lacks any one of these four essentials is not a contract in the eyes of the law. One that has them all is a legal contract even though it is represented only by a few words hastily scribbled on a scrap of paper or, as is frequently the case, by spoken words only. It is even possible to enter into a contract without speaking or writing a single word. When a man, accepting the silent invitation of a waiting street car, boards it for a ride, he implies by his conduct that in consideration of the ride he will pay the standard fare. Likewise the traction company implies, by permitting him to board the car, that it will furnish him with a ride in return for the "valuable consideration" of his fare. This has all the elements of a real contract.

Although the fundamental principles are very simple, the applications are so numerous and varied that only the legal specialist in the subject can hope to have a broad general knowledge of contracts. It is possible, however, for the average man to learn enough about the kinds of agreements with which he has to deal to enable him to avoid most of the pitfalls.

The power-plant engineer is particularly interested in contracts for the erection of new equipment or the repair of old. In work of this kind there is often no formal document, but merely a group of letters which, taken together, amount to a contract. The study and imitation of formal contracts or letters which have previously been satisfactory for similar work should prove very helpful. Aside from that the chief essential is a good supply of common sense combined with a clear idea of what is wanted. It should be made certain that there is a real "agreement" on all essential points. The exact manner of doing the work, materials to be used, required date of completion, amount and method of payment should be made so clear as to render any misunderstanding impossible. Great care should be taken to see that both parties are agreeing to the same arrangement throughout.

Ventilation Methods

FOR a number of years ventilating systems have been designed on the theory that an excess of carbon dioxide must be rigidly avoided by a plentiful supply of "fresh" outside air, whereas comparatively recent investigations have shown that even with an excess of carbon dioxide which would formerly have been considered actually poisonous, the difference between comfort and discomfort depends upon temperature, humidity and circulation, all of which may be controlled by simple and familiar methods.

The article by Mr. Hubbard on "Testing and Improving Ventilation," appearing elsewhere in this issue, goes into the subject thoroughly and brings out some interesting facts in an interesting way. A thorough assimilation of the basic principles set forth in this article will go far toward alleviating certain hot-weather conditions now approaching, especially in places where the much overburdened and objurgated electric fan has struggled valiantly but vainly to provide the desired "swept by ocean breezes" effect.

Men are plentiful now, and employers can pick and choose with the utmost freedom. Some employment managers, however, especially those whose youth and immaturity gives them an inflated sense of their own importance, seem to feel that the situation justifies brusqueness, and even downright discourtesy, to applicants for work. That attitude is wrong—not simply on general principles, but specifically because it will act as a boomerang that will hit back when times are more prosperous and workers more scarce. The employer who treats applicants for work like human beings in slack times as in boom times is laying the foundations of that intangible but most valuable thing called "goodwill." When jobs become more plentiful than workers, as they do every so often, such an employer finds that his plant is popular and that he has less difficulty in securing men than his less far-sighted neighbors.

CORRESPONDENCE

Saving by Proper Ash-Handling Equipment

Referring to the article on page 861 of the May 24 issue, entitled "Saving by Proper Ash-Handling Equipment," the subject is a very interesting one to the writer because of a long experience with systems for handling coal in boiler and gas houses and their two products, ashes and coke. I feel that the question of proper ash-handling equipment is not given sufficient consideration by the average power-house operator.

Mr. Herington puts his finger on an important factor that is frequently overlooked; that is, that ashes cost money to handle until they reach their final resting place. Many engineers provide for dumping their ashes from an overhead bunker into a railroad car. Other plants are designed to dispose of the ashes by dumping locally for filling in low land. In still others it is assumed that the ashes will be carted away by trucks, and the large New York power houses are provided with means for dumping the ashes at sea.

When it is remembered that the volume of ashes as compared to the volume of coal handled is very large, it becomes evident that in planning an ash-handling equipment no step from the time they drop from the grates until they are dumped on their final resting place should be overlooked.

To illustrate: In a number of plants the ashes are sluiced into a pit outside of the boiler house from which they are removed by means of a grab bucket and loaded into railroad cars. This may be a very neat solution to get the ashes from the boilers to the pit, but from the pit to the ultimate dumping point an expensive problem is encountered in winter time. Ashes do not flow out of hopper-bottomed cars when the discharge gates are opened, even when the ashes are dry. If they are wet and frozen, the railroad has a problem and is likely to make the owner of the ashes pay for this disposal.

An important point is not to assume that the ashes will be removed from the overhead bunker only by railroad cars. Provision should be made to remove them also by truck and, if convenient, by boats. The point is that it is impossible to foresee what the operating department may be up against a few years hence. Conditions change and it is the function of the engineer to provide a system that will lend itself to any future means of disposal.

Thirty years ago I thought that handling coal and ashes at a boiler house was a simple proposition. I feel now that there is a good deal to learn about the subject. I remember designing the coal- and ash-handling equipment in the first power houses that were built in Philadelphia, when trolley cars replaced horse cars, about thirty years ago. The ash-handling equipment provided wore out before the foreman could pack up his tools and leave the job. More adequate equipment, of course, had to be installed immediately, but it remained for the customer, with his more intimate knowledge of ashes and the general disposal problem, to design and install a more successful equipment.

Fortunately, good ash-handling apparatus is not necessarily expensive. It merely means that the equipment should handle any and all kinds of boiler-house rubbish at a high rate and at a low labor and upkeep cost. Good ash-handling systems are rare as compared to good coal-handling systems. This is because ashes are considered as rubbish of no value and therefore receive little consideration. As a matter of fact the ash-handling problem has always been much more difficult than that of handling coal.

Philadelphia, Pa. R. H. BEAUMONT.

Obtaining Average Temperature of Fuel Oil

Our plant has a storage tank that normally contains about 20,000 bbl. of fuel oil. When gaging this, we have experienced considerable trouble getting the correct temperature to use in making the temperature correction. Fuel oil expands or contracts one per cent for each 20 deg. F. It is evident that an error of 10 deg. would make a difference of 100 bbl. when the tank is full, which is considerable.

We tried taking temperatures at different points around the tank, and found that they varied as much as 12 deg. This was all near the surface, and we could not get the temperature near the bottom because the reading would change while the thermometer was being pulled up through the oil. Therefore it was necessary to guess as best we could the temperature to use, based on the average atmospheric conditions.

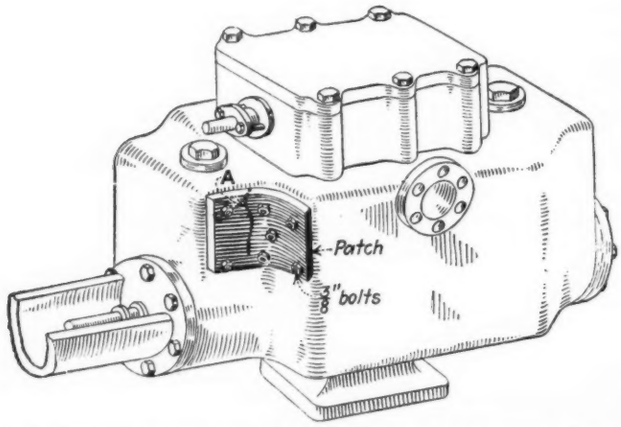
The pipe by which oil is taken from this tank is pivoted so that oil can be taken from any level by raising or lowering it with a windlass. We finally evolved the scheme of raising and lowering this pipe while the oil was being pumped out and reading its temperature as it ran into the small service tanks. This gave a good average reading and enabled us to make an intelligent correction for the temperature.

Wichita Falls, Tex. LESLIE R. GRAY.

Patch for a Cracked Pump Cylinder

A pump that was in practically constant use cracked at the point *A*. The design of the water cylinder was such that there was a bend at the point where the crack appeared.

It was decided that the crack could be patched, which necessitated a plate of the same curvature. A piece of $\frac{5}{16}$-in. plate was cut to the desired size and bent to



PATCH APPLIED TO A CRACKED WATER CYLINDER

conform to the shape of the cylinder. The surface to be covered by the patch was scraped clean, and it was then smeared with a coat of metal-cement compound, after drilling and tapping seven holes for $\frac{3}{8}$-in. cap bolts.

Before cementing and applying the patch, a small hole was drilled at the two extremities of the crack, preventing it from extending farther into the metal, and the holes were then plugged with brass.

When the cap bolts were tightened, the cement made a tight binder between the cylinder and the patch. The pump has been used for a number of years and it is still in apparently as good condition as it was when originally installed. D. HALSTED.

Baltimore, Md.

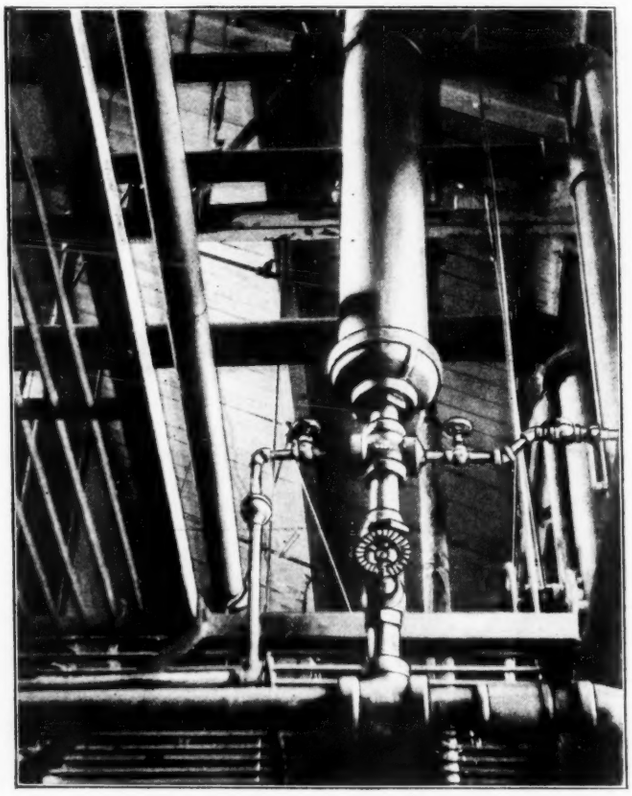
Eliminating Feed-Water Hammer

There was an awful pound in the feed-water line which caused continual trouble, due to leaky joints that it seemed impossible to keep tight. The duplex steam pump would every now and then miss a stroke, and there would be a tremendous slam in the pipes, and this could not be prevented unless the water was actually cooled, because there was only about 20 in. head over the valve deck and the water was kept at about 212 deg. F. On account of conditions the water level could not be raised.

After giving the subject considerable thought, I decided to try an air cushion as a cure for the trouble, and a 3 x 3 x 2½-in. tee was cut into the feed line. On the 2½-in. outlet a valve was placed and above that an air cushion made from six feet of 6-in. pipe. As soon as the water was allowed to surge through the valve, the pounding immediately stopped and everything was fine. In about 24 hours, however, the pounding gradually returned and was only cured by draining the water out of the air cushion, thus showing that the air had been absorbed by the water. Of course there really was not a very great air space, because the pipe was only filled with air at atmospheric pressure, which was greatly compressed by the feed-water line pressure of 135 lb. per square inch.

The next step was to insert a cross just above the valve, as shown in the illustration, and tap compressed air in at one side, threading the nipple in extra long so that an elbow could be put on, inside the cross, and a short nipple placed in that and pointing up to the air chamber. On the other side of the cross a drain valve was placed, leading into a reducing fitting so that the flow of water could be watched and thus it could be determined when the air chamber was properly drained. With this arrangement, as soon as the slightest pound was noticed the 2½-in. valve was closed, thus cutting out the air chamber. Next the drain valve was opened and the 100-lb. compressed-air line valve slightly opened, which allowed a flow of air to be directed into the air chamber, which displaced the water, causing it to flow out of the drain line.

As soon as the water was all drained out, the drain valve was closed and the compressed-air line valve opened, allowing the full 100 lb. air pressure to be



AIR CHAMBER AND AIR-CHARGING PIPING

established in the air chamber. Then the air valve was closed and the 2½-in. valve opened, and the air chamber was in service once more. One filling of the air chamber now lasts from four to six weeks, and no pound or jar can be felt in the feed line.

This air chamber has been such a success that I thought other readers who are having similar difficulties, would be interested in it, and if they wish to construct one they can get practically all the information from the illustration, which shows everything plainly except the 6-in. cap at the top.

Moline, Ill. GEORGE P. PEARCE.

Power Plant Data Forms

As a general thing, when the "Boss" or some other person interested asks for information upon a particular point in your equipment construction or some detail of operation, what do you do? About 80 per cent of the craft rush to their desk and dig up a small, much-used notebook, which gives, after much searching, a little data on the matter desired.

This is not as it should be. Charts and tables can be made that will give at a glance the information desired. In making these charts you become more familiar with your work, because you know all about it, you are interested in it, and you make yourself master of it.

Just think of an engineer being unable to tell the size of his engine cylinders—not because he has never ascertained this information, but he has forgotten.

In making up a data form, no detail should be neglected. Sizes of parts, pattern numbers, trade names, etc., are all of value and should be recorded. Sketches of pipe layouts and of wiring diagrams are of value.

The accompanying forms are some that I have found useful in my work. They cover standard conditions and, once made, are a reliable source of information.

In making use of these forms, give each piece of equipment a sheet to itself. For instance, if you have a turbine, with condenser, circulating pump, air pump, and hot-well pump, give each machine a thorough going over and check down the data you collect, and you will be surprised at the value this information will have in time. If the units are listed on separate data sheets, there is no chance to get the wrong size.

South Quincy, Mass. A. D. PALMER.

DATA FORM—ENGINE

Date when made up
Engine No. Maker
Type Age
Kind of engine
No. of cylinders Diam Length
Thickness Cylinder head thickness
Cylinder head bolts, No Size
How is cylinder supported
Piston type Area
Thickness Construction
Rings No. Width Diam
Piston rod diam Length Taper
Thread on end of rod at piston Crosshead
Follower bolts No Size
Crosshead type
Length Height Width
Wristpin, Diam Length
Shoes, length Thickness Material
Method of attaching wristpin
Connecting rod, type
Length Diam. min Max
Box adjustment
Wedge bolts No Size
Crank, type Throw
Crankpin diam Length
Eccentric rod diam Length
Eccentric throw
Rocker arms type
Length Travel Pin sizes
Bearings type Length
Material in boxes
Adjustment
Governor type R.p.m.
How driven
What does governor act upon
Engine r.p.m. Steam pressure
Foundation material Floor area
What does engine drive

DATA FORM—BOILER

Date made
Boiler No. State Std
Maker
Boiler used for
Business
Type of boiler
Diam Length Year bld
No. of drums No. of courses
Material
Brand and tensile strength
Thickness of plate Thickness of heads
Longitudinal joints
Efficiency of seams, long Girth
Pitch of rivets long seam x x
Pitch of rivets, girth seam x x
Riveting
Rivets Diam. of hole
Thickness of tube sheets
Tubes No. Diam Length ft in
Pitch of tube holes
Efficiency of ligament
Form of heads
Headers material w.-t. boiler
Distance upper tubes to shell
Area to be stayed, front head above tubes
Area to be stayed, back head above tubes
Area to be stayed front head under tubes
Area to be stayed, back head under tubes
Type of stays above tubes
Type of stays under tubes
Channel irons, size Location
Staybolt, pitch horizontal vertical
Diameter No. of rows Hole diam
Furnace diam Length Area
Thickness Type
Safety-valve type Size No.
Area of grate Length Width
Pressure gage No. of water glasses
No. of try cocks Blowoff size No.
Checks on return On feed line
Feed-pipe size Pressure allowed
Feed appliances
Stop-valve size Location
Factor of safety

DATA FORM—FLYWHEEL

Date when made up
Type of wheel No. of sections
Material in rim Arms Hub
R.p.m. Rim speed Ft.
Rim diam. Face Thickness
Rim joints, No. Rim bolts, No. and size
Hub diam. Length Bolts No. and size
Shaft diam. in hub In bearings
Distance between bearings c. to c
Length of bearings
Arms No. Cross-section Length
Weight of wheel
Weight of rim Key size
Method of attaching to shaft
Link thickness Length
Transmission
Belt width Length Thickness
Rope drive No. of grooves Size
Counterweight size
Counterweight location

PULLEY WHEELS

Date when made up
How numbered or known
For what used
Where located bld Floor Room
How driven
Diam. Face Thickness of rim
R.p.m. Rim speed
Material in rim Hub Arms
Bolts No. and size Rim Hub
Shaft Diam
Distance between bearings c. to c

DATA FORM—MOTORS AND GENERATORS

Date when made up
Serial No. Maker
Address of maker
Location Bld. Floor Room
What does motor drive
Open or closed type
How attached to support
Size of bolts and No. No. of poles
Type of fuse block
Distance between terminals
Capacity of fuses
Starter or controller
Maker No. Type Overload release
No. volt release
Distance from motor Source of power
Average load Hours run per day
Size of main lead
Voltage Amp. Kw. Hp.
Cycle Phase Current R.p.m.
Weight Floor space
Shaft diam. Length
Distance from c. to c. of bearings
Diam. of rotor Width

CONDENSERS

Date when made up
Maker
Type Diam. Length
Tubes material No. Diam. Length
Head material Thickness
Shell material Thickness
Pipe sizes Exhaust inlet Hotwell outlet
Circulating water inlet Outlet
Air line to air pump
Cooling surface in ft.

AIR COMPRESSOR

Date when made up
Maker Type of machine
Cylinders, diam. steam Air
Stroke R.p.m.
Cubic feet of free air per minute
Cubic feet of free air per revolution
Horsepower Air pressure designed for piston speed

DATA FORM—TURBINE

Date when made up Turbine No.
Location bldg. Floor Room
Manufacturer
Type Capacity Date of make
R.p.m.
Steam pressure at boilers Throttle
No. of stages Steam pressure each stage
Is steam taken from any stage for heating
Or other purpose
Condensing or non-condensing
Diam of casing hp. end Exhaust end
Diam. mainshaft Length of bearings
Distance from c. to c. of bearings
Lubrication Oil pressure
Type of valve gear
Type of governor How driven
Per cent of speed fluctuation
Type of independent speed limit device
Type of quick closing valve
Speed of limit device
Foundation material Size
What is driven by turbine
If elec. apparatus, Volts Current Phases
Frequency Amps. Kw.
Peak load Time of

DATA FORM—ELEVATORS

Date made up
No. and classification
Mfg. name
Address
Kind of power Transmission
Location of machine
Number of landings

Car

Builder Floor size
Capacity Speed
Enclosure Height
Top
Type of control
No. of car entrances
Type of car safety

Shaftway

Material
Length
Kind of doors Height
Distance from top to lower beam
Distance from bottom to pit bottom
Type of buffer
Type of limit stop
Size of supporting overhead beams No.
Type of counterweights

Machine

Type Voltage Amp. R.p.m. Current
Water supply Pressure
Safety valve set at
Maker
Type of machine limit stop
Type of slack cable device
Type of brake
Type of governor

Cables

Hoist, No. Diam. Material Fastening
Car c.w.
Drum c.w.
Operating
Governor
Cutoff
Centering
Size of sheaves, Hoist C.C.W. D.C.W.
Size of sheaves, Oper. Gov. Center

DATA FORM—PUMPS

Centrifugal Pumps

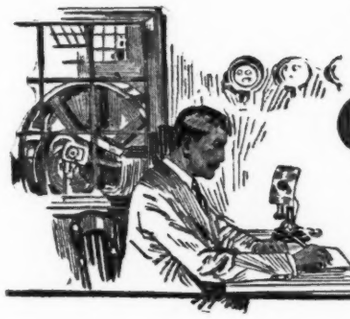
Date made up
Maker Pump No. Age
Type
R.p.m. G.p.m. Lift
Length of shaft Diam.
Floor space Impeller diam.
How attached to shaft
Pipe sizes, suction Discharge
Pump size How driven
Required hp. Average load
Stages
Distance between bearings
Packing rings No. Size
Bearing length
Distance from c. to c.
Head pressure

Air Pumps

Date made up
Maker Pump No. Age
Size Capacity
R.p.m.
Cylinder sizes, Steam Air
Rod diam. Length
Packing, No. of rings Size
How driven
What does pump serve?

Direct-Acting Steam Pumps

Date made up
Type Maker Age
No. of water cylinders Diam. Length No.
No. of steam cylinders Diam. Length No.
Type of valve gear
Valve-rod diam. Length
Piston-rod diam. Length
Packing rings for valve rod, No. Size
Packing rings for piston rod, No. Size
Strokes per min. G.p.m.
Floor space Weight of pump
Lift Head
Steam pressure required
Piping, Suction Steam Discharge Exhaust
Water-valve, type Diam. Thickness
No. suction Discharge



INQUIRIES OF GENERAL INTEREST

Preventing Deposit of Sediment in Condenser—Our refrigerating plant is using for condenser-cooling a water that carries much sediment. What can be done to prevent the settling of the sediment on the tubes? R. S.

If a supply of air under pressure is introduced into the water line to the condenser, the agitation will prevent the settling.

Testing for Air Leaks in Boiler Setting—What is the best method of testing for air leaks in a boiler setting? R. C.

Places for air leaks can be located by firing up strongly, opening the damper wide and suddenly closing it tight, when smoke will issue from all considerable cracks. Air leakage around door frames, blowoff pipes and through cracks in back connections, walls and arches are made evident by passing a candle flame near suspected places of air leakage.

Density of Water at Given Temperature and Pressure—What is the weight of a cubic foot of water at the temperature of 200 deg. F. when under a pressure of 150 lb. per sq.in. above the atmosphere? E. H. B.

The weight of a cubic foot of pure water when under atmospheric pressure and at the temperature of 200 deg. F. is 60.124 lb. per cubic foot. At that temperature the compressibility of water is about 0.0004 of its volume per additional atmosphere of pressure, and for 150 lb. per square inch, or about 10 atmospheres additional pressure, the weight per cubic foot would be about $\frac{60.124}{1 - (0.00004 \times 10)} = 60.148$ lb.

Cause and Repair of Bag in Boiler—What would cause about 2-in. bagging of the shell of a 48-in. diameter boiler over the fire? Is it dangerous to continue use of the boiler in that condition, and if so, how can the boiler be made safe by repairs? B. H. N.

The bag is a bulging from internal pressure of the boiler, possibly due to a very soft spot in the boiler sheet, but most likely it has resulted from the bottom of the shell becoming overheated from a deposit of oil or scale on the interior of the boiler. The original thickness of the material is reduced and the bulged form is a menace to safety, because the pocket formed is a place for scale and dirt to gather and is likely to become worse, even if extraordinary care is taken to keep the interior of the boiler clean. If the bagging cannot be bumped out after it has been drilled and heated and the drill hole subsequently filled with a rivet, the bag should be cut out and replaced by a patch fitted on the inside of the sheet.

Purpose and Operation of Vacuum Chamber on Pump—What is the purpose of a vacuum chamber on the suction side of a pump? C. F. D.

Properly speaking, there is no such thing as a "vacuum chamber" belonging to a pump, as the term is used with reference to an air vessel attached to the suction side of a pump to steady the flow. Its use is the reverse of that of an air chamber on the discharge side of a pump, whose purpose is to change an intermittent flow into a continuous flow; whereas the "vacuum chamber" has for its purpose the conversion of a continuous flow into an intermittent flow. The suction water coming to a standstill at the end of a stroke of the pump is brought to rest gradually by compression of the air in the so-called vacuum chamber, and when the next suction stroke begins the air expands with reduction of the suction pressure and helps the piston start the suction water in motion. The effect of the vacuum chamber, therefore, is to take water hammer away from the suction chamber of a pump, and it is most beneficial for that purpose on pumps that operate with high or long lifts and for pumps running at high speeds as then they operate with less noise and with less shock to moving parts.

Placing Engine on Center for Valve Setting—What is the method of placing an engine on a center for valve setting? T. E. S.

For valve setting, an engine must be placed accurately on center because when the crank is near the dead center the eccentric is in such a position that a slight rotation of the shaft causes considerable movement of the valve. To place the engine on a dead center, turn the flywheel until the cross-head is about one-half an inch from the end of its stroke and mark the position of the crosshead, as shown

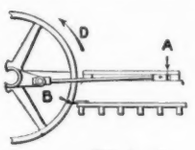


FIG. 1

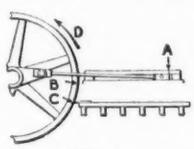


FIG. 2

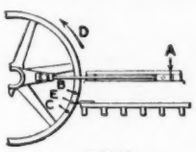


FIG. 3

at *A*, Fig. 1. Place a stationary pointer against the edge of the flywheel and make a mark on the flywheel opposite the pointer, as at *B*. Turn the engine until the crosshead completes the stroke and comes back until the mark *A* is in line again. The crank will now be in position as shown in Fig 2, as much above the center as it was before below the center. In this new position make another mark on the flywheel opposite the pointer, as shown at *C* in Fig. 2, and midway between the points *B* and *C* make another mark *E*, and turn the engine until the mark *E* is opposite to the pointer, as shown in Fig. 3. The engine then will be on the center.

In all operations of putting an engine on the center, care must be taken that the engine is always turned in the direction in which it is to run, because in that way the lost motion, backlash or play of the reciprocating parts will have the same effect in movement of the valve as under running conditions. Hence, if the running direction is the reverse of that indicated by the arrow *D* in the illustrations, locate the point *C* before locating *B*, and in any case, after locating the middle point *E* on the wheel, turn the wheel backward through about one-quarter of a turn before bringing the middle mark *E* up to the pointer.

Rating of Steam Turbines—How are steam turbines rated in power capacity? R. G. L.

Steam-turbine ratings usually are based on the maximum sustained load. Small turbines for driving pumps, blowers, etc., generally are rated in horsepower. Turbines employed to drive electric generators usually are rated in connection

with the generator, the combined unit or turbo-generator being rated in kilovolt-amperes at a certain power factor. A common practice is to assume 80 per cent power factor.

Determining Flue-Gas Temperatures—What is the best method of determining flue-gas temperatures taken in conjunction with flue-gas analysis? M. E. B.

The best method of testing temperatures, wherever possible, is by direct readings of mercurial thermometers. For taking flue-gas temperatures, the thermometer bulb should be protected from radiation and placed for taking the temperature of gases at the part of the flue from which the gas sample is taken. The thermometer stem should be long enough to reach through the flue covering to a place where the indications can be conveniently observed for obtaining an average of temperature readings.

Requirement of New Piston for Rebored Cylinder—Would a new solid piston be needed for the rebored cylinder of a 12 x 14 in. engine where the diameter of the bore is increased only $\frac{1}{16}$ in? A. R.

A solid piston should bear on the bottom of the cylinder, and for reducing the wear to a minimum, the piston diameter should be as nearly as possible of the same diameter as the cylinder bore to work without grabbing from unequal expansion of the piston and cylinder. With good lubrication a snap-ring piston $\frac{1}{16}$ in. less than cylinder diameter would remain tight for a considerable time without excessive leakage, but would require much more to be taken off in subsequent reboring of the cylinder. In any case the piston rod should work in a line parallel with the cylinder center line from proper adjustment of the cross-head shoes and with self adjustment of the gland of the piston rod stuffing box when the piston rides in the bottom of the cylinder, and if these conditions cannot be obtained with the old piston, then a new piston would be required.

Higher Vacuum-Gage Reading for Higher Barometer—Why are vacuum-gage readings corrected to a 30-in. barometer; and when a mercury-column vacuum gage shows 28.5 in. with a 29.6-in. barometer, why should the vacuum, when corrected to a 30-in. barometer be (30 − 29.6) + 28.5 = 28.9 in. vacuum, or higher vacuum in the condenser after correction than the actual reading of the vacuum gage? E. V. B.

The gage does not actually indicate vacuum; it shows how much the pressure in the condenser is less than the pressure of the atmosphere at the time and place, both pressures considered in inches of mercury. For comparison of vacua obtained under different atmospheric conditions, 30 in. is taken as a standard of barometric pressure. When the vacuum gage shows the difference to be 28.5 in. and the barometer reading is 29.6 in., then the condenser pressure would be 29.6 − 28.5 = 1.1 in. of mercury column pressure. But if there was 30 in. barometer, the same 1.1 in condenser pressure would give a vacuum-gage reading or difference of 30 − 1.1 = 28.9 in.

Variation from Equality of Cutoff—When Corliss-engine valves are set to give equal cutoffs for a particular fraction of stroke, why cannot equality of cutoffs be obtained with loads that require a different cutoff? R. L. G.

For different positions of the governor there are different relative angularities of the governor reach rods and from that cause, also from unequal wear in corresponding parts of the releasing gear, the increase or decrease of cutoff for a change of governor position is likely to be different. Further discrepancy is introduced by the angularity of the connecting rod unless compensated in the releasing gear. Fewer number of degrees rotation of the shaft and eccentric are accomplished during the half-stroke from the head end of the cylinder than from the crank end. When the governor connections are adjusted to give equality of cutoffs for a particular fraction of stroke, as for instance, one-quarter, for a load requiring greater length of cutoff the valves of both ends of the cylinder are held open during the same additional number of degrees rotation of the eccentric. This results in a larger proportion in change of the length of cutoff of the stroke from the head end than from the crank end. For the same reason a lighter load may result in more reduction of cutoff in the head end than in the crank end.

Dimensions of Standard Boiler Tubes—What are the principal dimensions of the different sizes of boiler tubes generally used for stationary boilers and the lengths required per square foot of heating surface? R. C. N.

The outside diameter is the normal diameter and the dimensions and lengths per square foot of heating surface of sizes more commonly employed for stationary boilers are given in the following table:

Normal Size on Actual External Diameter In.	Actual Internal Diameter In.	Thickness In.	Thickness B.W.G.	Length of Tube per Sq.Ft. of External Surface Ft.	Length of Tube per Sq.Ft. Internal Surface Ft.
1¾	1.560	0.095	13	2.183	2.448
2	1.810	0.095	13	1.909	2.110
2¼	2.060	0.095	13	1.698	1.854
2½	2.282	0.109	12	1.528	1.674
2¾	2.532	0.109	12	1.389	1.508
3	2.782	0.109	12	1.273	1.373
3¼	3.010	0.120	11	1.175	1.269
3½	3.260	0.120	11	1.091	1.172
3¾	3.510	0.120	11	1.018	1.088
4	3.732	0.134	10	0.955	1.024
4½	4.232	0.134	10	0.849	0.903
5	4.704	0.148	9	0.764	0.812
6	5.670	0.165	8	0.637	0.674

Flat Spots on Collector Rings of Generator—A 250-kw. 400-volt 60-cycle three-phase generator, operating at 200 r.p.m., has been giving trouble from the growth of flat spots through burning of the collector rings. The rings were ground down, but after a short time the spots showed up again and are now $\frac{1}{32}$ in. deep. There are only two spots on each ring. A test with a file failed to show any soft spots in the ring. What caused the trouble? R. M.

The burning of flat spots on the collector rings of an alternator may be due to a number of different causes. If the spots are equally spaced and always appear in the same place ,as seems to be the case with this machine, and no soft or spongy places can be detected in the metal, the trouble may be due to deformation of the rings by unequal expansion at high temperatures. Collector rings of the wheel type, with hub and spokes, are subject to this trouble, particularly if they have few spokes and are lightly built. If this is the cause, the burnt spots will probably appear at or near the spokes. The only remedy for this is to keep the rings heated to the operating temperature while grinding them. They will then be cylindrical at that temperature, though more or less deformed at lower temperatures. If the rings still give trouble after this operation, they should be changed for a more substantial construction, preferably with a web instead of spokes.

Burning of the rings is often caused by vibration, either of the brushes in the brush-holder, of the brush-holders, or of the machine itself. If the burning is localized and equally spaced around the ring, it is probably not caused by vibration of the brushes, but more likely results from a periodic defect, such as vibration of the machine due to unbalancing. Such vibration may also be set up by the prime mover, if the generator is driven by a reciprocating steam or gas engine.

The trouble may have an electrical source, such as surges in the armature. Such disturbances always induce similar trouble in the field windings, which may cause periodic burning of the rings. This would be most likely to occur if the generator were driven by a reciprocating engine or gas engine and was not of sufficient weight and diameter to provide the proper flywheel effect for the prime mover. This would set up a surge of current twice during each revolution and might produce two burned spots on the rings, always in the same place.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

The Possibilities of Co-operative Buying and Reserve Storage of Coal*

IN THE days before the war, the average consumer of bituminous coal paid little attention to the securing of his supply. Coal was usually plentiful and so cheap as to figure modestly in his total cost of production. Transportation conditions were such that he could count on regular deliveries. Little reserve storage was necessary—merely enough to equalize any slight check in the continuous movement of the coal traveling to him from the mines. As soon as broken down from its place in the seam in the mine, the coal was loaded into mine cars and dumped over the tipple into railroad cars, in which it at once continued its journey to the consumer's coal pile. Such was the regularity of this movement that the consumer had come almost to the point of considering coal in the same class as water or electricity, where he had but to turn on a switch to get what he was after.

The war, however, put an abrupt end to these conditions. The chief reason for the change was the inadequacy of the transportation facilities to carry the abnormally heavy burden. Coal became scarce at points of consumption. It became high-priced, partly because of increased costs of production and partly because of the struggle between buyers over a supply of coal insufficient to meet all demands. The plight of the municipal and state institutions, limited by law in their expenditures, and with few emergency funds available, and of the local public utilities operating on narrow margins between receipts and expenditures, is fresh in the memory. So also are the fuelless days of the winter of 1917-18. When the Armistice came, however, the pre-war conditions in respect to coal did not at once return, nor does there seem today to be any prospect of the return for years to come of the pre-war costs, prices and regularity of transport. It is therefore imperative that the consumer should take proper measures to meet this situation.

There is plenty of coal available for mining, there are mines enough already opened to furnish a supply adequate for any probable demand, domestic and export combined, but the cost of getting this coal to the mouth of the mine, has more than doubled. And the cost of getting it from the mine to the consumer's coal pile has in some cases tripled, while the pre-war regularity of transport has vanished.

Measures Adopted by Industrial Concerns

To meet the present-day conditions, many large consumers of coal are protecting themselves against inordinately high prices through more extensive use of contracts made with responsible operators or wholesalers. Such contracts call for large quantities of coal of a guaranteed standard of quality, delivered at suitable intervals. Furthermore, to protect themselves against the delays or breakdown of transportation facilities, these large consumers are establishing adequate reserve storage near their point of consumption. Most of the coal is put in storage during the period of low summer prices. By fall the storage facilities are loaded to their fullest capacity.

If such safeguards are adopted on the grounds of good business policy, merely to insure against the contingency of having to shut down from lack of fuel, how much more urgent are the reasons for similar precautions being taken by communities which must have a coal reserve to protect their municipal institutions, such as schools and hospitals, their local public utilities, and their medium-sized and small industrial consumers, and their domestic consumers as well, from the hardships of a coal famine, which would not only menace their pocketbooks, but affect vitally the health, protection and welfare of the whole community. To secure the necessary protection against such a contingency, there must be co-operative action on the part of the principal coal consumers in the locality. It is not reasonable to expect the coal operator and distributor to assume any increased financial burden or speculative risk, merely to protect consumers who can adequately insure themselves. The most practicable way of securing this protection for the community at a minimum cost is through the use of the combined purchasing power, together with the maintenance of a joint reserve storage. While such activities may be limited to merely industrial concerns, it will probably be found most advantageous to include the municipal and local public utilities among the co-operators. It will profit a manufacturer little to have a sufficient supply of coal if the local municipal institutions and public utilities must shut down or seriously curtail their activities for want of fuel.

Essence of the Co-operative Plan

The essence of the following co-operative plan for purchase of coal and for maintaining a joint reserve storage lies in making the transactions large enough to make it worth some person's while to see that they are carried on properly. The most efficient execution of this idea would probably be secured by making use as far as possible of existing facilities, supplementing them with new facilities only as a last resort. Every effort should be made to get the benefit of the experience of men who have spent years in the business of distributing coal. The success of any co-operative action on the part of consumers will be largely dependent on their working out in harmony with coal distributors the practical details safeguarding the interests of both consumer and coal distributor. It would be best for the co-operative organizations to act as far as possible, at least at first, as merely a supervising body, to insure the inforcement of contracts, rather than to set up an extensive organization to run the machinery of distribution and storage. So long as the commissions or charges for services performed under contracts are reasonable, this would be the best solution of the problem of distribution.

The co-operators would do well to form a company, preferably a non-profit stock company, which should act through an executive committee of its board of directors. This executive committee would have charge of the buying of the coal, distributing it to the members, and maintaining the joint storage reserve. It should have authority to employ the necessary personnel. Probably the cost of this service would best be borne by the members through assessments. It will be possible, if preferred, to add a service charge to the price at which the coal is insured to members. All coal bought by the organization should be invoiced to it, and then rebilled to the members, who will make their payments to the organization. This is so that the organization will have the legal title to the coal, which is desirable for settlement of difficulties with the producers and transporters in matters of grade, condition of coal, prompt shipments, etc.

Principal Requirements Outlined

Requirements for consumption: Information must first be gathered from the members showing the kind of coal at present used, its source, the tonnage required of each kind, the monthly or seasonable rate of consumption, the present storage facilities at the plant, the location of the plant with reference to rail or water delivery; also the possibilities of using cheaper fuel or otherwise decreasing the cost of operation by adjusting or modifying the present fireroom equipment.

Requirements for Joint Reserve Storage: Information must be gathered on the kinds of coal, and the minimum tonnage needed for reserve-storage. The location of the storage depot must be on land as cheap as possible, accessible from the supply by rail and water and within reach by rail and motor trucks to points of consumption. The storage plant should have adequate modern equipment for handling the coal economically and adequate protection against fire and theft. The character of some coals may make it desirable to store them under water.

Purchase of Coal: The minimum requirements, possibly amounting to 80 per cent of the average normal require-

*Abstract of article by David L. Wing published in *Coal Age* on June 9, 1921, page 1045.

ments, should be contracted for. Contracts for long terms and large quantities should preferably be made direct with the producers, and would probably be made most advantageously on some form of cost plus, properly safeguarded, however, to insure efficient operation. Desirable long-term contracts can also be secured on a basis of fixed price plus labor clause. The remainder of the requirements—up to the average normal requirements—should be bought on short-term fixed-price contracts, or in the open market, as may seem from time to time most advantageous. On signs of approaching exceptional demand or transportation difficulty, recourse should be had early to short-term contracts and market purchases to build up the reserve. Care must be taken, however, not to overload the reserve storage. All contracts should contain a guarantee as to composition and quality and adequate provision made for inforcing penalties in case of violations of this guarantee. Inspections should be made at such times as found desirable, not only at the mines, but also at the docks, and when necessary, at the destination, to check up such matters.

Water Borne Coal: If necessary for the organization to act directly in the matter of chartering boats, it would be desirable, at least at first, to contract with some regular chartering agency, for unless this work is skillfully handled, there is always danger of heavy demurrage charges at loading or discharging ports. Whenever possible, it would be desirable to make arrangements to handle incoming water-borne coal through existing dock facilities, on some suitable commission basis, safeguarded by stipulations that will insure the proper and prompt handling of the coal.

Advantages of Co-operation

The following advantages may be expected from the co-operative plan:

1. Getting coal at a price much below the spot-market price, or of the short-term contracts, or contracts made for small amounts, through the use of long-term contracts for large amounts. Under conditions insuring a producer of a constant market for a large part of his output, he can afford to make a relatively low price.
2. A more careful observance by the producer of the terms of his contract, both in regard to prompt and regular shipments, to grade and cleanliness.
3. Cheaper water transportation, through full cargoes, under arrangements reducing demurrage charges.
4. Prompt and regular distribution of coal, and the protection afforded by a joint reserve storage.

Such advantages could not be secured without undue expense by any but the largest consumers, if they acted singly, and would be wholly out of reach of small and medium-sized consumers, because of the magnitude of the transactions involved. They are, however, possible through intelligent co-operative action.

American Order of Steam Engineers and Supplymen Hold Convention

The American Order of Steam Engineers, in conjunction with the American Supplymen's Association, held their thirty-fifth annual convention at Allentown, Pa., during the week beginning Monday, June 6. The headquarters were the Penn Hotel, but it was necessary to scatter the delegates and guests to various other hotels, as several other conventions were being held in the city at the same time.

The meetings of the delegates were held on the main floor of Odd Fellows Temple, and the basement was tastefully decorated and divided into spaces for the use of the American Supplymen's Association. About one hundred booths were occupied by firms dealing in engineers' supplies. The exhibit remained open from 10 a.m. to 10 p.m. daily, and was generously patronized during the week.

There were more than sixty delegates present, and many important measures were brought forward, causing lively and interesting debate. The Smoot and Sterling bills, now before Congress, were discussed at length, and a committee of three was appointed to confer on the subject with Captain John M. Robinson, representing President Harding. The delegates seemed to favor the Sterling Bill, as it will be conducted under civil service, and promotion would depend upon the ability of the applicant. There is to be a big drive for enlarging the membership of the organization during the coming fall and winter, and a resolution was passed broadening the field of operation for this purpose. It was decided to continue the publication of the *Popular Engineer* by private contract.

The official opening of the exhibition took place on Monday evening. Ammon P. Dreisbach, chairman of the local committee, introduced Orrin E. Boyle, of Allentown, who cordially welcomed the convention to the city. He was followed by Colonel John P. Jackson, of the Department of Industrial Relations, of Philadelphia, who spoke instructively upon the subject of reconstruction. W. Scott Price, Supreme Chief Engineer, thanked the speakers, and declared the exhibit formally opened.

On Tuesday afternoon a memorial service, conducted by the Rev. G. W. Hangen, was held for the twenty-six members who had departed this life during the last year.

On Wednesday afternoon there was an outing at Dorney's Park. An interesting baseball game was played and an appetizing cold lunch was served.

On Tuesday afternoon there was an inspection of the plant of the Atlas-Portland Cement Co. at Northampton, Pa.

The leading feature of the convention was the vaudeville entertainment, under the auspices of the supplymen, on Thursday evening. The main auditorium of Odd Fellows Temple was filled with an appreciative audience, and an enjoyable night was spent.

The delegates elected the following supreme officers: W. Scott Price, past chief, Atlantic City, N. J.; George T. Crumm, chief, Baltimore, Md.; Thomas Higgins, first assistant chief, Philadelphia, Pa.; Harry Dunne, recording engineer, Philadelphia, Pa.; William S. Wetzler, corresponding engineer, Philadelphia, Pa.; William R. Smith, treasurer, Coplay, Pa.; George Landis, senior master mechanic, Reading, Pa.; William H. Stahler, junior master mechanic, Allentown, Pa.; John Crane, inside sentinel, Philadelphia, Pa.; E. H. Weider, outside sentinel, Coplay, Pa.; N. J. Feeley, chaplain, Philadelphia, Pa.; Thomas Small, trustee for three years, Atlantic City, N. J.

The American Supplymen's Association elected its officers for the ensuing year as follows: William Lindenfelser, past president, The Texas Co.; Roy C. Downs, president, Lord's Boiler Compound Co.; Andrew Lauterbach, secretary, The Lunkenheimer Co.; John W. Armour, treasurer, *Power*; J. Maurice Willets, vice president, Joseph Dixon Crucible Co.; George H. Dickel, director of exhibits, Cyrus Borgner Co.

Past Supreme Chief W. Scott Price was presented a traveling bag, and William Lindenfelser, retiring president of the supplymen, was given a purse of money.

The next convention will be held in the City of Philadelphia in June, 1922.

Roanoke River Project

The preliminary permit recently authorized for the Roanoke River Development Co., of Richmond, Va., is for a power project contemplated at Buggs Island, on the Roanoke River, near Clarksville, Va. It is proposed to erect a concrete dam 60 ft. in height and a power house with mechanical and electrical equipment sufficient to develop 10,000 primary horsepower. It is expected that 50,000 secondary horsepower will be available.

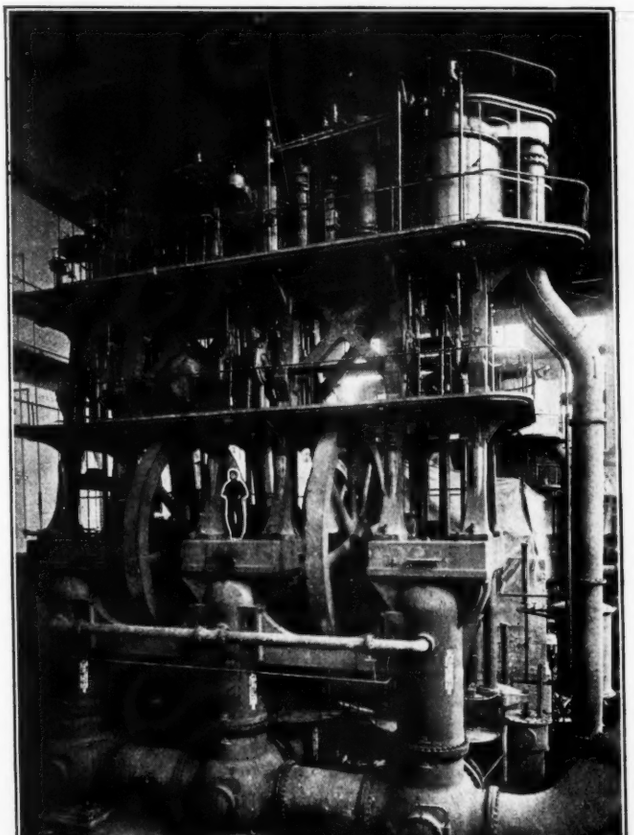
The plan is to use the primary horsepower for public-utility purposes in near-by cities and the secondary horsepower for the operation of a chemical plant in Richmond. The permit will be limited to a period of two years.

The Pueblo plant of the Arkansas Valley Railway, Light and Power Co. is completely submerged in water and mud. The switchboard on the mezzanine floor, which is six feet above the street level, is submerged nearly five feet. The plant operated until 9:15 Friday evening, June 3, when water and débris closed it. Five thousand gallons of transformer oil flooded the floors of the plant and was ignited by lightning. Strangely, the subsequent explosion of the oil put out this blaze, and this phenomenon undoubtedly saved the plant from destruction.

Development of Cleveland Water System and the Division Station

At the annual meeting of the American Water Works Association in Cleveland, Ohio, a paper was presented by J. N. H. Christman (mechanical engineer with Cleveland Water Works), which was of particular interest from the historical point of view. The main points of the paper are covered in the following paragraphs.

In 1854 work was started on the first water system of the City of Cleveland, Ohio, which at that time had approximately 30,000 inhabitants. A few facts about this original installation, which was put into operation in 1856, may be of interest. The water was drawn from Lake Erie through a 50-in. inlet pipe and was handled by a pumping station on Division Avenue. This station was equipped with two Cornish pumps, each having a daily capacity of 4,000,000 gal. The system included approximately thirteen miles of pipe and cost about $500,000.



ALLIS-CHALMERS 25-MILLION-GALLON PUMPING ENGINE
Height, 60 ft.; weight, 850 tons; horsepower, 1,150; head, 250 ft.; guaranteed duty per million B.tu., 170,000,000 ft.-lb.

At the time of its construction it was believed that the plant would be of sufficient capacity for the next fifty years. However, the growth of the city was more rapid than had been expected so that, starting in 1869, certain additions were made. These included a 5-ft. inlet tunnel extending more than a mile from the shore of the lake, new water mains, new boiler and engine houses and two new pumping engines each with a daily capacity of 10,000,000 gallons.

About 1882 work was started on new high-service and low-service reservoirs. Additional buildings and pumping machinery were installed at Division Station and about 92 miles of feeder and distributing mains were laid, establishing the low- and high-service pressure zones. These and other additions at the Division Station made it very unwieldy so that when the new Kirtland Station began operation in 1904, the Division Station was temporarily shut down for the purpose of increasing its inlet tunnels. This was made unnecessary for the time being because of the marked per capita reduction in water consumption due to the introduction of consumers' meters. In 1901, before metering had been adopted on a large scale, the daily per capita consumption was 176 gal. This steadily fell with the increasing use of meters until it reached 98 gal. in 1909. In 1901 a population of 396,000 consumed 69,600,000 gal. per day, while in 1909 a population of 540,000 used only 52,800,000 gal.! After 1909 the rapid growth of the city overbalanced the saving caused by the meter system and the total daily consumption began to increase once more.

In 1914 work was started on extensive additions and improvements at the Division Avenue Station. These included the following:

1. The construction of a filter plant with a daily capacity of 150,000,000 gallons.
2. The complete rebuilding of the Division Station.
3. The installation of three new service pumps, two of them of 25,000,000-gal. capacity for low service against a head of 250 ft. and the other one of 20,000,000-gal. capacity for high service against a head of 400 feet.
4. The rebuilding of three old triple-expansion pumps consisting of two 20,000,000 gal. engines for low service and one 10,000,000-gal. high-service engine.
5. The moving of a 30,000,000-gal. De Laval turbine pump from Kirtland to Division Station.
6. The installation of three low-lift centrifugal pumps, with a total capacity of 250,000,000 gal., for furnishing raw water to the filter plant.
7. The installation of the necessary water mains.
8. The installation of six Stirling boilers equipped with Riley stokers and designed to carry 200 lb. steam pressure with 100 deg. superheat.

Although these changes were completed in 1917, the last pump was not put on the line until February, 1918.

The boiler-room operating results obtained during the year 1920 were as follows:

Total steam generated, lb.		514,600,000
Total coal consumed, lb.		60,900,000
Actual evaporation per lb. of coal as fired, lb.		8.44
Cost of coal (at $4.60 per ton delivered) per 1,000 lb. steam, cents		27.2
Operating labor cost per 1,000 lb. steam, cents		8.62
Cost of routine repairs per 1,000 lb. steam..	Labor, cents	1.30
	Material, cents	2.89
Total cost per 1,000 lb. steam, cents		40.02

Other results of interest obtained for the year 1920 are tabulated below:

Water pumped into low-service mains	Amount, gal.	22,215,000,000
	Average head, ft.	191
Water pumped into high-service mains	Amount, gal.	7,497,000,000
	Average head, ft.	367
Average cost to pump one million gallons		$11.45
Average over-all duty of plant per 100 lb. of coal, ft.lb.		117,000,000

(Not corrected for steam supplied to filter plant.)

A project involving the issuing of $3,000,000 of bonds for extending and enlarging the water system and $25,000,000 for developing hydro-electric power is being discussed in Los Angeles. The location of the proposed development is in Boulder Canyon, on the Colorado River. It has been estimated that a dam at this point would be able to store approximately 25,000,000 acre-feet. The power would be used for pumping water needed in irrigation, for municipal purposes and for sale to private users.

The *North China Herald* reports signs of a revival in the demand for power plants in China after a lapse of about nine months. Inquiries are being made for power plants for practically all purposes, and considerable power apparatus has been imported recently.

In the present English shipping depression, according to *Marine Engineering*, motorships are being kept in service, while steamers are being laid up. This is taken as an indication of the greater economy of the motor-driven vessels.

N. A. S. E. Holds Three State Conventions

THE twenty-sixth annual convention and mechanical exhibition of the New York State Association of the N. A. S. E. was held in New York City, June 9, 10 and 11, with headquarters at the McAlpin Hotel.

The sessions of the delegates were held in the Blue Room of the hotel, and the display of mechanical devices and engine-room equipment was located in the handsome grillroom. Many new things in the engineering field were on exhibition. Ninety booths were occupied by the leading supply houses, and during the three days, especially in the evenings, the display room was thronged with interested observers. The Ladies Auxiliary had a large booth, and the members were very much in evidence at all times. The proceeds of the Auxiliary are devoted to the comfort of indigent engineers and the sale of tickets was very big.

There were upward of eighty delegates registered, but the meeting room showed a much larger attendance, because of visiting engineers from the near-by cities. The convention was the best in the association's history.

On Thursday evening T. J. Condon, director of exhibits, officially opened the mechanical exhibition, after which Francis P. Bent, representing Mayor Hylan of New York, welcomed the visitors enthusiastically. The response was ably made by Frederick Felderman, chairman of the convention committee.

At the opening exercises on Friday morning Mr. Felderman introduced Staff Captain John Allen, of the Salvation Army, who offered the invocation. Fiorello H. La Guardia, president of the New York City Board of Aldermen, welcomed the convention to the city, and wished for a return visit next year. Arthur E. Dowd, president of the State Association, thanked Mr. La Guardia in behalf of the delegates and guests, for his kindly reception. John R. Young, of the New York Merchants Association, spoke of the value of conventions to the industrial world and hoped the visit of the guests would be pleasurable and profitable. He was responded to by Past National Presidents John J. Callahan and William J. Reynolds.

At the Saturday afternoon session, James D. Taylor, secretary of the Life and Accident Department, delivered an interesting address, and urged that the local bodies should interest themselves further in the Life and Accident Department and preach the wisdom of becoming members thereof. At this meeting memorial services for those who had passed away during the year were held.

The feature closing the convention was the banquet, entertainment and dance in the main ballroom of the McAlpin. More than four hundred delegates, guests and ladies were seated at the prettily decorated tables at eight o'clock on Saturday evening, and a good dinner was served.

The election of state officers resulted as follows: Arthur E. Dowd, past president, Rochester; Samuel Thackaberry, president, New York City; William B. Smith, vice president, Niagara Falls; William Roberts, secretary, Yonkers; William Downes, treasurer, New York City; William Jobson, conductor, Brooklyn; Emiel Carrita, doorkeeper, Middletown; A. S. Bennett, chaplain, Brooklyn; George Van Vechten, state deputy, Rochester.

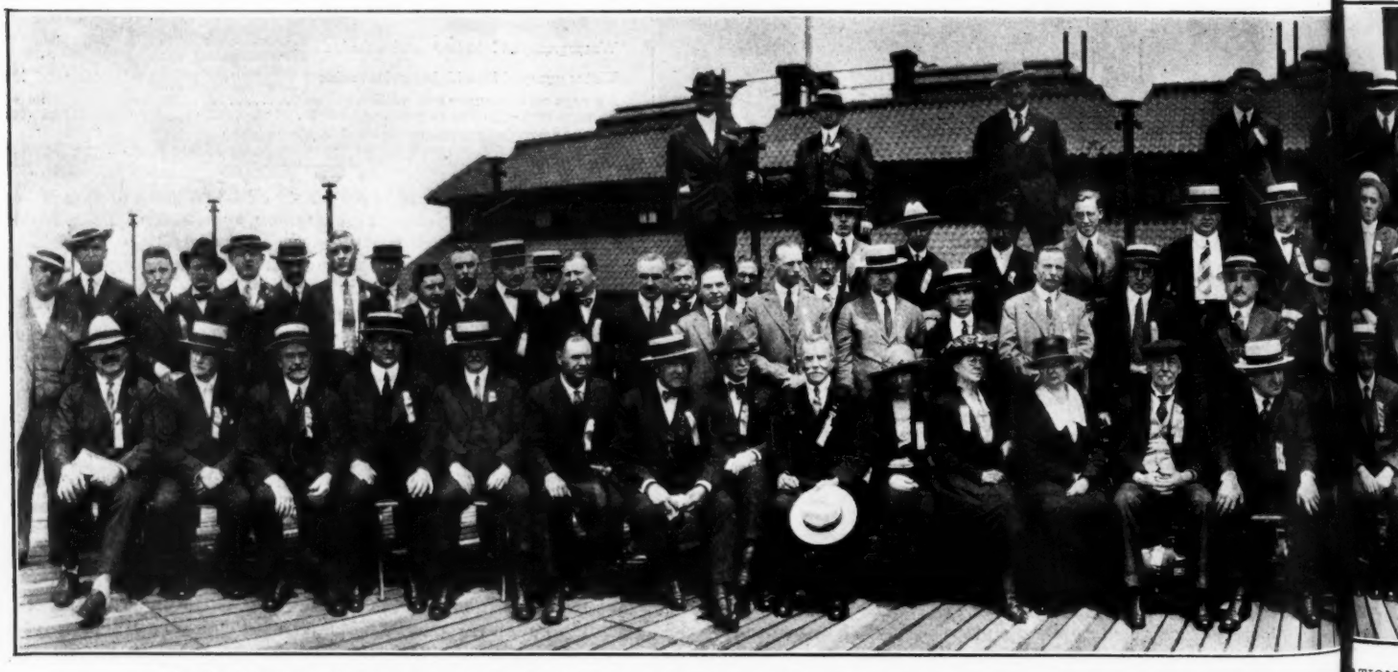
The executive convention committee included Frederick Felderman, chairman; Charles Baxter, Samuel Thackaberry and T. J. Condon.

Owing to the success of the affair it was unanimously voted to hold the 1922 convention in New York City, with the McAlpin Hotel as the headquarters, in the month of June.

The Illinois State Convention

From June 8 to 10 at the Municipal Pier, Chicago, the Illinois State Association of the National Association of Stationary Engineers held its seventeenth annual convention. It was the first convention ever held at the pier and was the best and biggest in the history of the organization. Delegates seated numbered sixty-one, but the attendance of engineers ran up into the hundreds. The exhibits far exceeded any previous effort of the state association and in fact were almost on a par with the display at the annual national convention. There were 226 booths occupied by 193 exhibitors. Both the supply men and the engineers were so well pleased with the results that the sentiment was unanimous to return to Chicago next year and to have an exhibit of even greater proportions in the same place.

On Wednesday morning C. W. Naylor, acting as chairman, called the convention to order. Addresses of welcome were made by John E. Ericson, representing the mayor, and



DELEGATES AND VISITORS ATTENDING THE TWENTY-SIXTH ANNUAL NEW YORK STATE CONVENTION OF

Arnold Joerns, of the Association of Commerce. Responses were made by State President Fred Gielow, National President Alfred Johnson, and National Secretary F. W. Raven. The convention appreciated the honor of having these two national officers present. With the preliminaries over, the chair was turned over to Fred Gielow, state president, who proceeded to appoint the usual committees and deliver the presidential address. There were a number of recommendations in his address, which later were put to a vote before the convention and were unanimously passed. The first of these resolutions proposed that the State Association take action against the reclassification of engineers which is to be called for in a bill to be presented shortly before Congress. If the bill is passed, all stationary engineers that are employed by the Government will be classified as enginemen.

Other resolutions proposed: That the association's work be made simple and practical; that $150 be set aside for propaganda work; that a committee of six be appointed to decide upon the 1922 convention city and to audit the books of the 1921 convention; and that the association co-operate with other engineering organizations in behalf of license legislation.

At a later session the state deputy, M. E. Harris, reported a gain in membership of 158 during the year, increasing the total to 1,514. Considerable discussion followed with a view to arousing the interest of the various delegates, so that they might go back home and be the means of starting an active campaign for a great increase in membership. During the last year three locals, Nos. 1 and 28, of Chicago, and No. 17, of Moline, have made a good showing in this direction; the flag annually awarded for the greatest percentage of increase in membership was given to No. 1 of Chicago.

A humorous incident marked the closing session. With the delegates serving in the capacity of a jury, Joe O'Connell accused Messrs. Jim Harkins, Charles Fiske and Victor Bastian of conspiracy, or collusion, to make the present convention the greatest ever. The verdict was "guilty" and the penalty inflicted was a handsome auto-luncheon set to Mr. Harkins and a $100 check each to Messrs. Fiske and Bastian. The farce was admirably carried out and appreciated by all present.

Officers chosen for the coming year were: Fred Gielow, president; A. C. Grantz, vice-president; Stanley Raven, secretary-treasurer, and M. E. Harris, recommended to the national president as state deputy.

The New Jersey State Convention

The thirtieth annual state convention of the National Association of Stationary Engineers of New Jersey was held in Jersey City on Saturday and Sunday, June 4 and 5. The sessions of the delegates were held in the meeting rooms of the Jersey City Association, 574 Newark Ave. The first floor of this building was occupied by twenty-six of the leading firms displaying their various engine-room supplies and power-house equipment.

There were in attendance upward of 75 delegates, representing the several associations in the state. Although comparatively small in area, New Jersey has the honor of holding the second largest membership in the organization. Harmony prevailed throughout the meetings, and several matters of interest to the association were debated and passed upon.

The opening exercises took place at 2 o'clock Saturday afternoon, with George G. Armitage, state president, occupying the chair. He addressed the delegates briefly, thanking them for their good work during the last year, and then introduced A. Harry Moore, Commissioner of Parks, who welcomed the convention to Jersey City. Mr. Moore was ably responded to by Henry Cozens, William J. Reynolds and John J. Callahan, past national presidents. The necessary committees were then appointed and an adjournment was taken until the next morning at 9 o'clock.

On Saturday evening a smoker and entertainment was held. The performance pleased the large audience. Good things to eat and drink were served in abundance.

At the close of the Sunday afternoon session the delegates and guests, through the courtesy of the Tide-Water Oil Co., were taken on a sight-seeing trip through the boulevards of Hudson County, stopping at the plant for an inspection, where luncheon for more than 300 was served.

Retiring State President George T. Armitage was the recipient of a leather traveling bag, the gift of the supplymen.

Following is a list of the newly elected state officers: Charles L. Johnson, president; John Mycock, vice-president; Samuel A. Clark, secretary; William Sissler, treasurer; E. W. Matthews, doorkeeper; William P. Brennan, conductor; John J. Reddy, state deputy.

The Ladies' Auxiliary livened up the convention by their presence and did considerable good work.

Elizabeth was selected as the place for the next state convention in June, 1922.

ATIONAL ASSOCIATION OF STATIONARY ENGINEERS ASSEMBLED ON ROOF OF THEIR HOTEL IN NEW YORK CITY

Washington News

Proposed To Abolish Power Commission—Senator Frelinghuysen To Demand Compulsory Fact-Finding in Coal Industry

By Paul Wooton
Washington Correspondent

A proposal that the Federal Power Commission be "abolished and all duties, powers, equipment and all that pertains to said commission be transferred to the Department of Mines and Mineral Resources and placed under its jurisdiction and made a part thereof" is contained in the bill drafted by Senator Shortridge of California.

In the new Federal Department of Mines and Mineral Resources, which Senator Shortridge would set up, he proposes to have a Bureau of Power Development. This bureau would be under the immediate direction of a chief engineer, who would be appointed by the President and who would receive a salary of $7,500. He suggests two consulting engineers for the bureau, each to receive $5,000 per annum. These engineers are to be detailed for the service, one by the Secretary of War and one by the Secretary of Agriculture.

The Secretary of Mines under this bill would have authority to transfer to the Bureau of Power Development the work of the United States Geological Survey dealing with the gaging of streams and the investigation of water resources. In addition this bureau would be the custodian of the records of the Superpower Survey.

The new department as proposed by Senator Shortridge would absorb the work now being done by the Geological Survey, the Bureau of Mines, the War Minerals Relief Commission, the California Débris Commission, the Federal Power Commission, and the Bureau of Explosives of the Interstate Commerce Commission, as well as such portions of the work of the Bureau of Standards, the General Land Office and the Indian Office as pertain to mineral lands or the regulation of mineral activities on the public or Indian lands.

Compulsory Investigation to Be Demanded

Adoption of compulsory fact-finding in securing pertinent data as to the production, transportation and marketing of coal will be insisted upon by Senator Frelinghuysen. He has conferred at length with representatives of the producers, wholesalers, retailers and the anthracite operators. Despite the insistence of these groups that all the necessary information can be obtained on a voluntary basis, the New Jersey Senator insists that the public will be better protected if this bill, providing penalties for non-compliance or false returns, is adopted.

Senator Frelinghuysen is of the opinion that the majority of the operators are willing to accept this legislation. The principal opposition is coming from the wholesalers and the retailers, he says—the very groups from whom it is most necessary to ascertain how their charges are made up.

The principal apprehension of the operators seems to be that the bill may be amended during its course through Congress so that it will be more drastic in its final form than it is at present.

The consideration of the bill will be begun by the Senate in the near future, it is believed.

Italy has made rapid progress in hydro-electric development even during the war, according to a report from H. C. MacLean, commercial attaché in Rome. It is estimated that the yearly electric-power production increased from 2,500,000,000 kw.-hr. in 1915 to 4,000,000,000 at the present time. Plants of capacity aggregating 400,000 hp. are now under construction, and development of an additional 1,000,000 hp. is under consideration.

The Nevada Valleys Power Co. expects to build a 3,500-hp. plant on the Truckee River, 15 miles east of Reno, during 1921. The plant will be called the Ditho Power House and will supply power for municipal, mining and farming needs.

Engine-Building Industry in 1919

The United States Census Bureau is now sending out preliminary statements of the 1919 census of manufactures, in which may be found some data bearing on the manufacture of steam and internal-combustion engines and steam and water turbines. Traction engines, locomotives, parts of engines and a few miscellaneous products were also included in the summary of the industry.

The number of establishments making such products decreased, according to the report, from 446 in 1914 to 371 in 1919, although the value of their products increased in the same time from $72,121,000 to $464,770,000. The natural inference from these figures is that the tendency has been toward fewer establishments and a higher production for each.

The value of stationary and portable steam engines manufactured increased only from $5,402,000 in 1914 to $7,617,000 in 1919, whereas the value of stationary steam turbines increased in the same period from $3,689,000 to $9,837,000. Although these figures bear out the obvious fact that turbines are becoming more popular than engines, they indicate that reciprocating engines still have a large field that has not been taken over by the more modern turbine.

In 1919 the largest number of establishments in the industry in any one state was in Ohio, where there were 44; 36 were in Wisconsin, 35 in Michigan, 34 in Pennsylvania, 31 in New York, 25 in Illinois, 22 in California and the remaining 144 scattered among 30 other states in varying quantities.

Of all these establishments the chief product of 60 was steam engines; of 199, internal-combustion engines; of 85, traction engines; of 10, waterwheels, motors, turbines and hydraulic rams; and of 17, locomotive engines, parts of engines and locomotives, and other foundry and machine-shop products and repairs.

These figures for the year 1919 are sent out by the bureau with the understanding that they are subject to whatever revision may be necessary from a further examination of the original reports.

Portland, Oregon, is making arrangements to hold a world's fair in 1925 and is boosting the project already with colored posters on which a hydro-electric plant is featured. Power development is one of the most important causes of Western prosperity and advancement, and the indications are that it will come in for no small amount of interest at the coming fair.

A total of $306,274 worth of air-compressing machinery was exported by the United States in April, 1921, according to the Department of Commerce.

Defective Tools Are Dangerous

HOW NOT TO DO IT
A safety poster of the Ocean Accident and Guarantee Corporation

New Publications

THE EFFICIENCY OF PUMPS AND EJECTORS. By E. C. Bowden-Smith, M. I. Mech. E. (Great Britain). Published by D. Van Nostrand Co., New York City, 1920. Cloth; 5½ x 8½ in.; 205 pages; 28 illustrations. Price, $4.

This book treats in a comprehensive manner the various methods of raising sewage where gravity discharge is not possible. The discussion throughout represents British practice modified by the author's experience in the Egyptian Civil Service. The word "efficiency" in the title, if limited to its customary restricted meanings, does not at all indicate the scope of the book. Although considerable space is given to the mechanical, "commercial" and "sanitary" efficiencies of the various methods of pumping sewage, this is amplified by discussions of almost every phase of the subject. The practical considerations involved in the selection, installation and operation of the necessary equipment are discussed at great length. Although there are a number of tables and curves, the style is mainly conversational and the book is practically free from anything of a mathematical nature. The viewpoint is distinctly that of the practical operating man who is well acquainted with the actual conditions to be encountered. The relative merits of reciprocating pumps, centrifugal pumps and compressed-air ejectors for this class of work are given careful consideration. The author lays particular stress on the point that the handling of sewage, on account of the air and solid matter which it contains, presents problems quite different from the pumping of clear liquids. For many situations the author seems to feel that the air-ejector system is practically superior in spite of its low mechanical efficiency. After making the due allowance for the difference between American and British practice, this book would seem to be of considerable value to engineers directly interested in the handling of sewage. Those who are interested only in the use of pumps and air ejectors for other purposes will find little of practical help.

PROCEEDINGS OF THE PHILADELPHIA AND NATIONAL CONFERENCES ON THE CONSTRUCTION INDUSTRIES

The Industrial Relations Committee of the Philadelphia Chamber of Commerce and the National Federation of Construction Industries held conferences at Philadelphia and at Chicago recently at which the construction industries were the subject of a great number of papers and considerable discussion. This book, which is 8 x 10½ inches and contains 254 pages, is a verbatim report of the speeches and discussion at both conferences. A complete table of contents and a reference index are also included. It may be purchased at cost from the Industrial Relations Committee, 1414 South Penn Square, Philadelphia, Pa.

BEARING ALLOYS

The United States Bureau of Standards has prepared a 16-page pamphlet on "Some Properties of White Metal Bearing Alloys at Elevated Temperatures," by John R. Freeman and R. W. Woodward, of the Bureau. Special apparatus for testing bearing metals is described and results of compression and hardness tests on five typical white metal alloys at temperatures up to 100 deg. C. are given. The booklet is "Technologic Paper No. 188 of the Bureau of Standards," and may be had for 5c. from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Personals

H. W. Hough, previously with the Daniel M. Leuhrs Co., has taken a position as research engineer with the Cleveland Electric Illuminating Co.

C. H. Shepherd has started a private practice as a consultant in street-lighting and power-system engineering. He was previously electrical engineer in charge of Lincoln Park, Chicago.

E. D. Frohmann, of the S. Obermayer Co., has gone to Europe, where he will make a special study of the application of high temperature cements for boiler and metallurgical furnace linings.

W. T. Neal has been appointed rate engineer for the Pacific Power and Light Co. and the Portland Gas and Coke Co. He was previously with Henry L. Gray, a Seattle consulting engineer, and before that with the Public Service Commission of Oregon.

Charles D. Terry, assistant to the general superintendent of the National Tube Co., was married on June 1, 1921, to Miss Catharine McQuade. They are to spend their honeymoon in France, Switzerland, England and Scotland. Mr. Terry was a member of the committee of the A. S. M. E. that went to Europe some time ago in an effort to form an international threading standard for pipe fittings, valves, etc.

Business Items

The Everlasting Valve Co. has moved its executive and sales department from New York City to its new office building at 49 Fisk St., Jersey City, N. J.

The Adapti Co., Cleveland, Ohio, maker of flexible conduit fittings, has purchased the property and building formerly occupied by the Cleveland Refrigerator Co., at East 72d St. and Oakwood Ave., thus securing about four times as much space at it had before.

Trade Catalogs

Greene, Tweed & Co., 109 Duane St., New York City, have ready for distribution a new 7x10-in. 36-page catalog completely describing and illustrating the "Rochester" automatic lubricator, which is of the force-feed type.

The Hagan Corporation, Pittsburgh, Penn., has just received from the printer a 6x9-in. 12-page booklet on the Hagan De-Concentrator, which is used for continuously, automatically and mechanically removing scale-forming matter from the boiler while in operation.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoting	June 7 1921	June 14 1921
Pool 1,	New York	$3.50	$3.25@3.65
Pocahontas,	Columbus	3.30	3.35@3.50
Clearfield,	Boston	2.35	1.85@2.00
Somerset,	Boston	2.95	2.40@3.10
Pittsburgh,	Pittsburgh	1.95	1.85@2.00
Kanawha,	Columbus	2.25	2.15@2.25
Hocking,	Columbus	2.15	2.00@2.25
Pittsburgh No.8	Cleveland	2.30	2.00@2.20
Franklin, Ill.,	Chicago	3.00	2.50@3.50
Central, Ill.,	Chicago	2.50	2.25@2.75
Ind. 4th vein,	Chicago	3.15	2.75@3.50
Standard,	St. Louis	1.75	1.65@1.85
West Ky.,	Louisville	2.10	1.50@2.25
Big Seam,	Birmingham	2.60	2.25@2.75
S. E. Ky.,	Louisville	2.35	2.00@2.50

New York—On June 14, Port Arthur light oil, 23@25 deg. Baumé, 4¼c. per gal. 30@35 deg., 6c. per gal. f.o.b. Bayonne, N. Y.

Chicago—June 11, for 24@28 deg. Baumé, 45@50c. per bbl.; 32@34 deg. 1⅞@2c. per gal. In tank cars f.o.b. Oklahoma refinery, or freight adjusted.

St. Louis—June 11, prices fo.b. cars, tank lots; 24@26 deg. Baumé, 50c. per bbl.; 26@28 deg. 55c.; 28@30 deg., 60c.; 32@34 deg. 2c. per gal.

Pittsburgh—On June 13, f.o.b. refinery; Pennsylvania, 36@40 deg., 3⅜@4c. per gal.; Oklahoma, 24@30 deg., 45c. per bbl., gas oil, 32@34 deg., 1⅜c. per gal., 36@38 deg., 2¼c. 38@40 deg. 2⅜c.

Philadelphia—On June 14, 26@28 deg. Baumé, Oklahoma, 3¼c. per gal.; 30@34 deg., Oklahoma (group 3) 2⅜c. per gal.

Cincinnati—June 13, for 22@28 deg. Baumé, 6⅝c. per gal.

Cleveland—June 13, for 22@28 deg. Baumé, 5½c. per gal.

New Construction

PROPOSED WORK

Conn., New Britain—Commercial Trust Co., 274 Main St., has engaged A. Hopkins, Archt., 101 Park Ave., New York City, to prepare plans for a 6 story, 60 x 120 ft. bank and office building on Washington and West Main Sts. About $600,000.

N. Y., Fulton—The city voted $415,000 bonds to build a high school.

N. Y., Oswego—The City will receive bids until July 12 for a 3 story high school on 1st St. About $500,000. J. A. Randall, S. A. & R. Bldg., Syracuse, Engr. and Archt.

N. Y., Wellsville—The Village Water & Light Dept. voted bonds to build a rapid sand filter plant including pumps and water tube boilers. E. J. Rowe, Supt.

Pa., Dormont (Pittsburgh P. O.)—The Bd. Educ. received bids for a high school and boiler house from Harry Wisner, Butler, $236,463; Hughes Foulkrod Co., Oliver Bldg., Pittsburgh, $239,750; Henry Skenk Co., Century Bldg., Pittsburgh, $271,815. Noted May 23.

Pa., Meadville—The Bd. Educ. plans to build a 2 story, 200 x 200 ft. high school here. About $350,000. W. G. Eckles, New Castle, Archt.

Pa., Phila.—The Dept. of City Transit, 1211 Chestnut St., will receive bids until June 28, furnishing substation equipment, to include 12 panel switchboard and starting panels, high-tension bus compartments with buses, switches, current potential transformers, auxiliary machinery, conduits, station wiring, hign and low tension. H. H. Quinly, 1211 Chestnut St., Engr.

N. C., Durham—The City will receive bids until July 15 for a 3 story school. About $350,000. Milburn, Heister & Co., Union Savings Bank Bldg., Archts.

N. C., Elizabeth City—The Bd. of Graded School Trustees plans to build and equip schools. About $350,000. E. F. Aydlett, Chn.

N. C., Greensboro—The North Carolina College for Women plans to build 3 dormitories and additions to present building. About $700,000. J. L. Nelson, Chn. of the Bldg. Com. Harry Barton, Archt.

Miss., Jackson—T. C. Link, Supervising Archt., Dir. of Pub. Wks., P. O. Box 636, will receive bids until June 24 for steam fitting and the radiation of a dormitory, mess hall and kitchen at the Agricultural and Mechanical College, Starkville; 4 dormitories in Ricks Hall addition, University of Mississippi, Oxford; Academic Bldg., Mississippi Normal College, Hattiesburg; 2 dormitories in Industrial Training School, Columbus; 1 dormitory in Alcorn A. & M. College, Alcorn; 1 Nurses' Home in South Mississippi Charity Hospital, Laurel.

Miss., Jackson—T. C. Link, Supervising Archt., Dir. Pub. Wks., P. O. Box 636, will receive bids until June 24 furnishing:

Two hand fired stokers for 250 hp. water tube boilers.

Two 125 kva. 3 phase, 60 cycle 220 volt, a.c. generators, direct connected to poppet valve steam engine.

One 150 hp. 3 phase, 60 cycle 220 volt, a.c. motor with pulley and slide rails.

One motor driven centrifugal pump with capacity of 60 gal. per minute against 150 ft. head.

One motor driven centrifugal pump with capacity of 60 gal. per minute against 30 ft. head.

One open type feed water heater with capacity of 20,000 lb. per hour.

One closed type hot water generator or heater with capacity of 2,000 gal. per hour.

To be installed in State Insane Asylum.

La., New Orleans—The Girod Service Station, 918-922 Girod St., is in the market for a small upright steam boiler, about 8 or 10 hp. (used). J. W. Twining, Genl. Mgr.

Tenn., Memphis—Jones & Furbringer, Archts., Porter Bldg., will receive bids about July 1 for a 14 story, 102 x 150 ft. hotel on Main and Adams Sts. for Tri-State Hotel Co. About $1,000,000. Barnett, Haynes & Barnett, Century Bldg., St. Louis, Mo., Archts.

O., Cincinnati—The Bd. Educ., Denton Bldg., will receive bids about July 15 for a 2 story school including a steam heating system on Madison Ave. About $400,000. S. Hannaford & Sons, 6th and Vine Sts., Archts. A. M. Robinson, 511 West Court St., Engr.

O., Cincinnati—The Globe Chemical Co., 727 Ridgeway Ave., is in the market for a small steam pump to have a daily capacity of 500 gal.

O., Cleveland—The Cleveland Roman Catholic Diocese, c/o Rev. J. P. Farrell, Superior Ave., is having plans prepared for an 8 story official building on East 12th St. About $500,000. E. T. P. Graham, 171 Newbury St., Boston, Mass., Archt.

O., Cleveland—The Union Trust Co. had plans prepared for a 20 story, 260 x 385 ft. bank and office building including a steam heating system on Euclid and Chester Aves., and East 9th St. Graham, Anderson, Probst & White, Railway Exchange Bldg., Chicago, Ill., Archts.

Ind., Bloomington—The Indiana University plans to enlarge and remodel heating plant in connection with proposed 2 story commerce building. Total cost about $295,000. W. L. Bryan, Pres.

Ind., Michigan City—The Michigan City Hotel Corp. plans to construct a 4 story, 80 x 155 ft. hotel and store building including a steam heating system on Michigan and 7th Sts. About $400,000. Nicol, Scholer & Hoffman, Ross Bldg., Lafayette, Archts.

Mich., Detroit—The Fellowcraft Club, Washington Blvd., is having plans prepared for an 8 story, 135 x 200 ft. clubhouse including a steam heating system on Second and Ledyard Sts. About $1,250,000. Verner, Wilhelm & Molby, Book Bldg., Archts.

Mich., Port Huron—The Bd. Educ. engaged Van Leven, Schilling, Keough & Reynolds, Archts., 3440 Cass Ave., Detroit, to prepare plans for a 2 story, 85 x 116 ft. addition to Fillmore School; 82 x 102 ft. addition to Harrison School; 30 x 43 ft. addition to Buchanan School and an 88 x 166 ft. addition to the Lincoln School. Steam heating equipment will be installed in same. About $325,000.

Ill., Chicago—L. E. Bouchard & Co., Archts., 30 North Dearborn St., is preparing plans for a 9 story, 120 x 265 ft. bank and office building including a steam heating system on Howard and Marshfield Aves. About $750,000. Owner's name withheld.

Ill., Chicago—The Illinois Supply Co., 225 North Michigan Ave., plans to build a 1 story, 200 x 1,250 ft. clothing factory including a steam heating system on Natchez and Grand Aves. About $1,000,000. A. H. Spitz, 105 West Monroe St., Archt.

Ill., Oak Park—G. H. Cook, 4938 West Jackson Blvd., Chicago, will build a 5 story, 140 x 140 ft. apartment house including a steam heating system on Washington Blvd. and Oak Park Ave. About $500 000. Work will be done by day labor.

Wis., Milwaukee—M. Tullgren & Sons, Archts., 415 East Water St., will receive bids about June 18 for a 7 story, 63 x 200 ft. apartment on Prospect Ave. for H. Marggraff Co., 964 10th St. About $500,000.

Wis., New London—The Wisconsin Cabinet & Panel Co. has engaged Cahill & Douglas, Engrs., 217 West Water St., Milwaukee, to prepare plans for a 250 hp. power boiler.

Wis., Waukesha—I. J. Frisch and associates, c/o Z. E. Smith, Archts., 305 East 55th St., Chicago, Ill., are having preliminary plans prepared for the construction of a 3 story, 150 x 200 ft. hotel including a 50 x 75 ft. high pressure steam plant. About $500,000.

Wis., Wausau—St. Mary's Hospital is having plans prepared for a hospital addition and boiler house. About $275,000. E. Brielmaier & Sons Co., 632 Bway., Milwaukee, Archts.

Ia., Arnolds Park—The city will receive bids until June 22 for a water-works system including an 8 x 14 ft. pump house, chlorination plant, pumping equipment, etc. About $32,000. W. E. Buell Co., Davidson Bldg., Sioux City, Engr.

Ia., Bedford—The City will receive bids until June 21 for improvements to the water-works system including a dam, low service pump house, pumps and motors; (a) 900 gal. per min. horizontal centrifugal pump connected to 15 hp., 220 volt motor, to operate against 40 ft. head; (b) pump of 630 gal. per min. capacity connected to 15 hp., 220 volt motor, to operate against a 40 ft. head; (c) two pumps of 200 gal. capacity each, connected to 3 hp. motors; (d) one 200 gal. per min. pump connected to 3 hp. motor; (e) two 150 gal. per min. pumps connected to 2 hp. motors; (f) one 150 gal. per min. pump connected to 2 hp. motor. About $30,000. Henningson Eng. Co., Natl. Bldg., Omaha, Neb., Engr.

Minn., Duluth—Victor Essting Hibbing is interested in corp. which is having plans prepared for a 7 story, 180 x 200 ft. apartment house including a steam heating system on London Rd. and 12th Ave., East, here. About $1,000,000. German & Jenssen, 411 Exch. Bldg., Archts. and Engrs.

Kan., Pittsburg—The Masonic Bldg. Association, c/o E. V. Lanyon, is having preliminary plans prepared for a 3 story Masonic Temple including a steam heating system. About $400,000. W. Schmitt, 1634 West 10th St., Oklahoma City, Okla., Archt.

S. D., Beresford—The City, c/o W. M. Yorker, clk., plans to improve water-works system and power plant. About $70,000. Dakota Eng. Co., Mitchell, Engrs.

Mo., Brookfield—The City will receive bids until June 26 for two 500 g.p.m. pumps, 30 ft. head; one 300 g.p.m. pump, 200 ft. head; two 700 g.p.m pumps, 300 ft. head, gasoline engine driven fire pumps, etc. All pumps to be horizontal centrifugal type. About $140,000. E. M. Lomax, Chn. of the Bd. E. E. Harper, 3031 Park Ave., Kansas City, Engr. Noted March 15.

Mo., St. Louis—Liberty Hospital, c/o J. Grenshaw, Pres., Pendleton and Delmar Aves., plans to build a 4 story, 150 x 200 ft. hospital including a steam heating system on Taylor and Washington Sts. About $500,000. Heffenstellar-Hirsch & Watson, Chemical Bldg., Archts.

Tex., Dallas—The Y. W. C. A., 1509 Commerce St., is having plans prepared for a 4 story Y. W. C. A. building on Jackson and Prather Sts. About $350,000. C. D. Hill & Co., Sinnyster Bldg., Archt.

Tex., Kerrville—Phelps & Dewies, Archts., 715 Gunter Bldg., San Antonio, will receive bids about August 15 for a 1 and 2 story, 20 x 25 ft. tubercular sanitarium including complete power plant for Amer. Legion Memorial, Austin.

Tex., San Antonio—R. Cameron, 1116 Central Trust Bldg., will receive bids about July 15 for a 2 story, 120 x 200 ft. lodge including complete power and heating plant on 500 4th St. for Masonic Lodge, Losoya St. About $1,000,000. H. M. Greene & Co., Dallas, Associate Archts.

Col., Denver—The Presbyterian Church is having plans prepared for a 5 story 22 x 222 ft. church. About $1,000,000. Fisher & Fisher, Archts.

Cal., Long Beach—Deeble and Chapman and associates, City Natl. Bank Bldg., plan to build a 12 story, 100 x 100 ft. office building on American Ave. and Bway. About $1,250,000. W. H. Austin, Archt.

Ont., Brantford—City will soon receive bids furnishing 140 hp. electric motor and switchboard in connection with sewage pumping plant. F. P. Adams, City Hall, Engr.

Ont., Sarnia—Sarnia Genl. Hospital soon receives bids for a 1 story, 54 x 58 ft. central heating plant on George St. About $25,000. C. C. Woods, 217½ Christina St., N., Archt.

Ont., Seaforth—R. Bell Engine & Thresher Co. is in the market for 15 or 20 hp., 3 phase, 25 cycle, 220 volt electric motor.

Ont., St. Catharines—The Bd. Educ., 11 Welland Ave., engaged S. B. Coon & Son, Archts., 4 St. Thomas St., Toronto, to prepare plans for a college building including a steam heating system on Catharine and Maple Sts., here. About $350,000. C. A. McBride, 13 Welland Ave., Secy. and Treas.

Ont., Windsor—The Windsor and Walkerville Bds. of Educ. plan to build a technical school, here. About $750,000. George A. Courtenay, Secy.

CONTRACTS AWARDED

Mass., Boston—The Beacon St. Trust Co., 75 Tremont St., awarded the contract building 8 story, 54 x 108 ft. and 35 x 4[illegible] ft. apartment house on Beacon St. to C. A. Newhall, 73 Tremont St. About $500,000.

Mass., West Springfield—United Electric Light Co., 73 State St., Springfield, has awarded the contract for a 1 story electric substation at the Eastern State Exposition Grounds to E. T. Davis & Son, 157 Lebanon St., Springfield. About $12,500.

Pa., Altoona—The School Dist. has awarded the contract for a 2 story, 50 x 121 ft. power and heating plant on 6th Ave to J. C. Orr & Son, 7th Ave. and 5th St., at $70,472; for furnishing two 374 hp. boilers, complete with settings, etc., to the Babcock & Wilcox Co., 85 Liberty St., New York City, at $70,916; for coal and ash handling equipment to the Dravo Doyle Co., Diamond Bank Bldg., Pittsburgh, at $12,170; for stokers, to the Combustion Eng. Corp., Combustion Eng. Bldg., New York City, at $11,910; for furnishing and installing one 200 kw. turbine with six switchboards, 250 kw. motor and six 115-230 transformers, to the General Electric Co., Witherspoon Bldg., Philadelphia, Pa., at $18,537. Noted May 31.

Ill., Chicago—A. J. Jordan, 111 West Washington St., will build a 5 story, 85 x 175 ft. apartment house including a steam heating system on 43d St. and Drexel Blvd. About $600,000. Work will be done by day labor. Noted May 10.

S. C., Canton—City has awarded the contract for the installation of a steam heating system and plumbing in proposed school to J. L. Powers, Bennettsville, $6,130 and $7,132 respectively.

Mich., Battle Creek—The Bd. Educ. has awarded the contract for a 60 x 80 ft. high pressure steam heating plant in connection with the proposed 3 story, 95 x 400 ft. vocational school, to R. G. Phelps.

Mich., Detroit—The Water Bd., East Jefferson Ave., has awarded the contract for furnishing labor and material for the construction of a superstructure for a low lift pumping station at the Waterworks Park to W. H. Mueller, 1711 Ford Bldg., at $120,750. Noted May 23.

Mich., Northville—Dept. Health, 1415 St. Antoine St., Detroit, has awarded the contract furnishing refrigerating equipment to Kroeschell Bros., 1008 Majestic Bldg., Detroit, $29,870; for refrigerators, to Chrysler & Koppin, 2625 West Warren Ave., Detroit, $18,485; for switchboard, to J. H. Busoy, 826 Cherry St., Detroit, $8,990.

Wis., Jones Island (Milwaukee P. O.)—City Sewerage Comn., Milwaukee, has awarded the contract for the foundation only, of main power house, here, to Dahlman Constr. Co., 456 Bway., $79,670.

Ia., Des Moines—T. W. Carpenter, c/o Keystone Coal Mining Co., 407 Crocker Bldg., has awarded the general contract for an 8 story, 66 x 125 ft. office building on 10th St. and Grand Ave. to A. H. Neumann & Co., 519 Hubbell Bldg.; for installation of electric wiring to Electric Service Co., 1211 Grand Ave.; for heating and plumbing to Van Dyck Heating & Plumbing Co., 1111 Walnut St.; for elevators to Otis Elevator Co., 623 6th Ave. About $350,000.

Minn., Eveleth—The Bd. Educ. has awarded the contract for the installation of steam heating and ventilating systems in a 3 story, 128 x 262 ft. school to Stack Bros., 217 East 1st St., Duluth, $57,700.

Okla, Tusla—D. Hunt, 1539 South Madison St., has awarded the contract building 10 story theater and office building including a steam heating system to A. F. Wasielewski Co., Basement Catholic Church. About $510,000.

Col., Denver—The School Dist. No. 1 has awarded the contract for installing a heating system in the proposed Junior High School on West 41st Ave. and King St. to the Johnson Davis Plumbing and Heating Co., 425 15th St., at $74,553. Notew May 17.

News of Opportunities

See the

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